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TRANSPORT PRICING METHODOLOGY

Assessing the greenhouse gas impacts of transport pricing policies

ICAT SERIES OF
ASSESSMENT GUIDES

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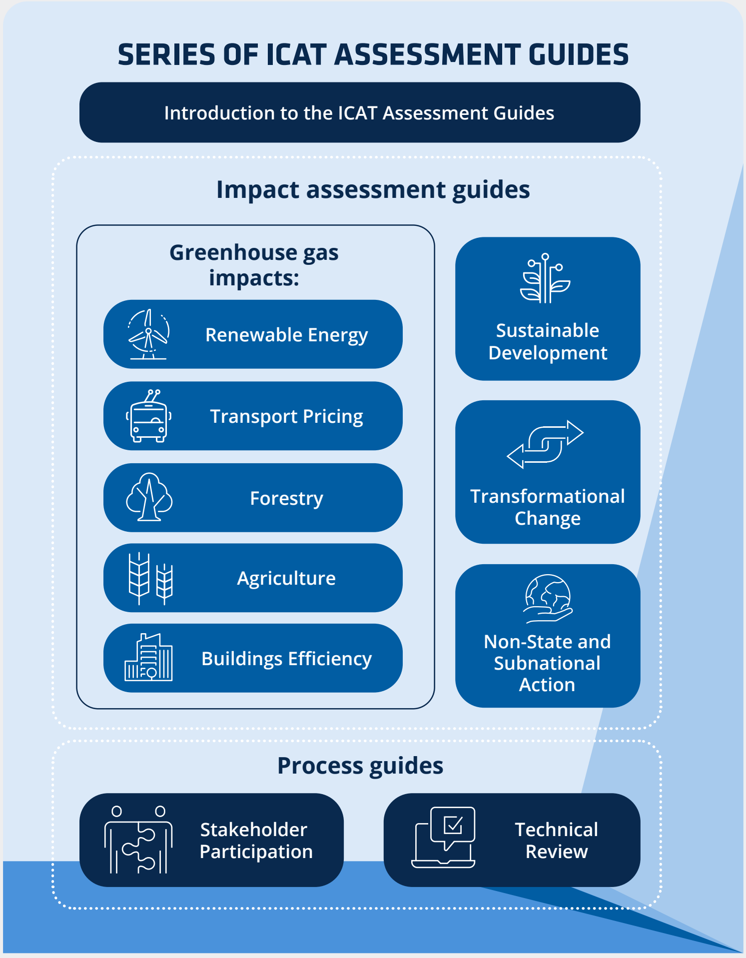
How to use the Assessment Guides

This guide is part of a series developed by the Initiative for Climate Action Transparency (ICAT) to help countries assess the impacts of policies and actions. It is intended to be used in combination with other ICAT assessment guides and can be used in conjunction with other guidance.



Contents

PART I

Introduction, objectives, steps and overview of pricing policies

1 Introduction

The transport sector is responsible for approximately 18% of global greenhouse gas (GHG) emissions,[1] and experts predict that economic growth could cause transport activity to double by 2050. A fundamental transformation is needed if the sector is to play its part in the transition to net zero global GHG emissions in the second half of the 21st century. Pricing policies, such as removing fuel subsidies or increasing fuel taxes, can play an important role in reducing GHG emissions. These can be considered win–win policies because of the multitude of environmental, social and economic benefits they bring.

In this context, there is an increasing need to assess and communicate the impacts of transport policies to ensure that they are effective in mitigating GHG emissions, and helping countries meet their sectoral targets and national commitments. The Initiative for Climate Action Transparency (ICAT) Transport Pricing Methodology *helps policymakers assess the impacts of pricing policies in the transport sector and improve their effectiveness. It can play a critical role in providing the information needed for preparing reports under the Paris Agreement's enhanced transparency framework and for the United Nations Sustainable Development Goals.*

[1] Huizenga and Peet (2017).

1.1 Purpose of the methodology

This document provides methodological guidance for assessing the GHG impacts of pricing policies in the transport sector. Specifically, the methodology provides a stepwise approach for estimating the impacts of higher fuel prices using price elasticities of demand. Other methods are provided in less depth for estimating the impacts of vehicle purchase incentives and road pricing policies.

This methodology is part of the series of ICAT guides for assessing the impacts of policies and actions. It is intended to be used in combination with any other ICAT documents that users choose to apply. The series of assessment guides is intended to enable users who choose to assess GHG, sustainable development and transformational impacts of a policy to do so in an integrated and consistent way within a single impact assessment process. Refer to the ICAT *Introduction to the ICAT Assessment Guides*[2] for more information about the ICAT assessment guides and how to apply them in combination.[3]

1.2 Relationship to other guidance and resources

This methodology uses and builds on existing resources mentioned throughout the document, such as the GIZ *Reference Document on Measurement, Reporting and Verification in the Transport Sector,*[4] as well as additional resources listed in Appendix B.

The methodology builds on the Greenhouse Gas Protocol *Policy and Action Standard*[5] (© WRI 2014; all rights reserved) to provide a detailed method

[2] https://climateactiontransparency.org/wp-content/uploads/2020/01/Introduction-to-the-ICAT-Assessment-Guides.pdf

[3] An executive summary of this Guide has been published separately. https://climateactiontransparency.org/wp-content/uploads/2020/01/Transport-Pricing-Methodology-Executive-summary.pdf

[4] Available at: http://transferproject.org/wp-content/uploads/2014/10/Reference-Document_Transport-MRV_final.pdf.

[5] WRI (2014).

for specific transport pricing policies. The *Policy and Action Standard* provides guidance on estimating the GHG impacts of policies and actions, and discusses many of the accounting concepts in this document, such as baseline and policy scenarios. This methodology adapts the structure, and some of the tables, figures and text from the *Policy and Action Standard*, where relevant. Chapters 1, 2, 4, 5, 6, 11 and 12, and the glossary include elements drawn from the *Policy and Action Standard*. Figures and tables adapted from the *Policy and Action Standard* are cited, but for readability not all text taken directly or adapted from the standard is cited.

A full list of references is provided at the end of this document.

1.3 Intended users

This methodology is intended for use by policymakers and practitioners seeking to assess GHG impacts in the context of development and implementation of nationally determined contributions (NDCs), national low emission development strategies, nationally appropriate mitigation actions (NAMAs) and other mechanisms. The primary intended users are developing country governments and their partners who are implementing and assessing transport pricing policies. Throughout the document, the term "user" refers to the entity implementing the methodology.

The main emphasis of the methodology is the assessment of GHG impacts. Impact assessment can also inform and improve the design and implementation of policies. Thus, intended users include any stakeholders involved in the design and implementation of national transport policies, strategies, NDCs or NAMAs, including research institutions, businesses and non-governmental organizations.

1.4 Scope and applicability of the methodology

This document provides general principles and concepts, and a stepwise method for estimating the GHG impacts of the following types of transport pricing policies,[6] which are described in more detail in Chapter 3:

- **Fuel subsidy removal.** Subsidies that reduce the price of vehicle fuel below its fair-market cost are removed.

- **Increased fuel tax or levy.** The tax imposed on each unit of vehicle fuel is increased. The tax may include general taxes that apply to many goods and special taxes specific to vehicle fuel.

- **Road pricing (road tolls and congestion pricing).** Motorists pay directly for driving on a particular roadway in a particular area. Road pricing has two general objectives: revenue generation and congestion management.

- **Vehicle purchase incentives for more efficient vehicles.** Governments increase the fuel efficiency of the vehicle fleet and/or promote a shift to lower-carbon fuels by providing incentives for the purchase of selected vehicles. This policy is most applicable to electric, plug-in hybrid-electric, hydrogen-fuelled and other vehicles that are not powered by gasoline or diesel. It is applied by governments through lower purchase taxes, purchase rebates, income tax credits and lower vehicle taxes.

The methodology does not include non-motorized transport, nor every fuel or vehicle type. However, the methods and calculations in this document can be applied to other transport or fuel types, depending on country-specific needs.

The methodology does not cover all transport policies, but rather aims to fill gaps in existing guidance. Users can refer to the *Compendium on Greenhouse Gas Baselines and Monitoring: Passenger and Freight Transport*[7] for descriptions and links to guidance on other transport policies or actions. Appendix H lists the full criteria used to choose the scope of the methodology.

[6] Throughout this document, where the word "policy" is used without "action", it is used as shorthand to refer to both policies and actions. See Glossary for definition of "policy or action".

[7] Available at: www.international-climate-initiative.com/fileadmin/Dokumente/2017/170602_Compendium_GHG_Monitoring_Transport.pdf.

This methodology is organized into four parts (see Figure 1.1). It details a process for users to follow when conducting a GHG assessment of pricing policies. It provides guidance on defining the assessment, an approach to GHG assessment including ex-ante (forward-looking) assessments and ex-post (backward-looking) assessments, and monitoring and reporting. Examples from an assessment in Indonesia for subsidy removal and vehicle purchase incentives are included in Sections 9.2 and 10.2.5 to illustrate how to apply the methodology. The full report of the assessment conducted in Indonesia will be published on the ICAT website.[8]

The methodology is applicable to policies:

- at any level of government (national, subnational, municipal) in all countries and regions (depending on the approach chosen)
- that are planned, adopted or implemented
- that are new policies; or extensions, modifications or eliminations of existing policies.

FIGURE **1.1**

Overview of the methodology

Part I: Introduction, objectives, steps and overview of pricing policies

Understand the purpose and applicability of the methodology (Chapter 1)
Determine the objectives of the assessment (Chapter 2)
Understand transport pricing policies (Chapter 3)
Understand assessment steps and principles (Chapter 4)

↓

Part II: Defining the assessment

Clearly describe the policy to be assessed (Chapter 5)
Indentify GHG impacts, and define GHG assessment boundary and assessment period (Chapter 6)

↓

Part III: Assessing impacts

Calculate base year emissions using approach A, B or C and project baseline scenario (Chapter 7)
Choose price elasticity values and calculate GHG impacts ex-ante using approach A, B or C (Chapter 8)
Assess GHG impacts ex-post (Chapter 9)
Optional: Estimate GHG impacts for vehicle purchase incentives and road pricing (Chapter 10)

↓

Part IV: Monitoring and reporting

Identify parameters and monitor performance over time (Chapter 11)
Report the results and methodology used (Chapter 12)

[8] www.climateactiontransparency.org

1.5 When to use the methodology

The methodology can be used at multiple points throughout the policy design and implementation process, including:

- **before pricing policy implementation** – to assess the expected future impacts of a pricing policy (through ex-ante assessment)
- **during pricing policy implementation** – to assess the impacts achieved to date, ongoing performance of key performance indicators, and expected future impacts of a pricing policy
- **after pricing policy implementation** – to assess what impacts have occurred as a result of a pricing policy (through ex-post assessment).

Depending on individual objectives and when the methodology is applied, users can implement the steps related to ex-ante assessment, ex-post assessment or both. The most comprehensive approach is to apply the methodology before policy implementation, regularly during implementation and again after implementation. Users carrying out an ex-post assessment only can skip Chapter 8. Users carrying out an ex-ante assessment only can skip Chapter 9.

1.6 Key recommendations

The methodology includes key recommendations that are recommended steps to follow when assessing and reporting impacts. These recommendations are intended to help users to produce credible and high-quality impact assessments that are based on the principles of relevance, completeness, consistency, transparency and accuracy.

Key recommendations are indicated in subsequent chapters by the phrase “It is a *key recommendation* to …”. All key recommendations are also compiled in a checklist at the beginning of each chapter.

Users who want to follow a more flexible approach can use the methodology without adhering to the key recommendations. The ICAT *Introduction to the ICAT Assessment Guides* provides more information on how and why key recommendations are used within the ICAT assessment guides, and on following either the “flexible approach” or the “key recommendations approach” when using the documents. Refer to the *Introduction to the ICAT Assessment Guides* before deciding which approach to follow.

1.7 Alignment with the enhanced transparency framework of the Paris Agreement

This methodology can help countries to fulfil their accounting and reporting requirements under the enhanced transparency framework of the Paris Agreement. Specifically, the methodology can help countries understand the impacts of transport pricing policies, estimate baseline emissions and GHG impacts, conduct projections, and monitor progress over time using indicators and parameters. This enables countries to account for their contributions and track progress towards implementation and achievement of their NDCs. Alignment of indicators and parameters (i.e. using the same indicators and parameters to assess the impacts of a transport pricing policy and to meet reporting requirements of the transparency framework) is recommended for the following:

- Estimating baseline emissions and GHG impacts. Align input parameters used to estimate baseline emissions and GHG impacts of transport pricing policies with the input parameters used for GHG accounting of NDCs (see Chapter 7).
- Projections and assessment period. Align the parameters and assessment period used to develop projections for transport pricing policies with the parameters and time frame used to meet reporting requirements of the transparency framework (see Chapters 7 and 8).
- Monitoring and tracking progress toward NDCs. Indicators and parameters used in this methodology to monitor transport pricing policy implementation can also be used to track progress towards implementation and achievement of an NDC. Some indicators suggested in this methodology can be used to track sustainable development impacts (see Chapter 6).

1.8 Process for developing the methodology

This methodology has been developed through an inclusive, multi-stakeholder process convened by ICAT. The development is led by INFRAS (technical lead) and Verra (co-lead), who serve as the secretariat and guide the development process. The first draft was developed by drafting teams, consisting of a subset of a broader Technical Working Group (TWG) and the secretariat. The TWG consists of experts and stakeholders from a range of countries identified through a public call for expressions of interest. The TWG contributed to the development of the technical content of the methodology through participation in regular meetings and written comments. A Review Group provided written feedback on the first draft of the methodology. ICAT's Advisory Committee, which provides strategic advice to ICAT, reviewed the second draft.

The second draft was applied by ICAT participating countries and other non-state actors to ensure that it can be practically implemented. The current version of the methodology was informed by the feedback gathered from that experience.

More information about the methodology development process, including governance of the initiative and the participating countries, is available on the ICAT website.[9]

All contributors are listed in the Contributors section.

[9] https://climateactiontransparency.org

2 Objectives of assessing the GHG impacts of pricing policies

This chapter provides an overview of objectives users may have in assessing the GHG impacts of pricing policies. Determining the assessment objectives is an important first step, since decisions made in later chapters are often guided by the stated objectives.

Checklist of key recommendations

- Determine the objectives of the assessment at the beginning of the impact assessment process

Assessing the impacts of transport pricing policies is a key step towards identifying opportunities and gaps in effective GHG mitigation strategies. Impact assessment supports evidence-based decision-making by enabling policymakers and stakeholders to understand the relationship between pricing policies and expected GHG impacts. It is a *key recommendation* to determine the objectives of the assessment at the beginning of the impact assessment process.

Examples of objectives for assessing the GHG impacts of a policy are listed below. The ICAT *Sustainable Development Methodology* and *Transformational Change Methodology* can be used to assess the broader sustainable development and transformational impacts of transport pricing policies, and users should refer to these methodologies for objectives for assessing such impacts.

2.1 Objectives of assessing impacts before policy implementation

- **Improve policy design and implementation** by understanding the impacts of different design and implementation choices.
- **Inform goal-setting** by assessing the potential contribution of policies to national or subnational goals, such as NDCs
- **Assess the transformational potential** of a policy and use that to seek funding from finance institutions supporting transformational action.

2.2 Objectives of assessing impacts during or after policy implementation

- **Assess policy effectiveness and improve implementation** by determining whether policies are being implemented as planned and delivering the intended results.
- **Learn from experience** and share best practices about policy impacts.
- **Track progress towards national goals** such as NDCs and understand the contribution of policies to achieving them.
- **Inform future policy design,** including reformulation of NDCs towards enhanced ambition, and decide whether to continue current actions, enhance current actions or implement additional actions.
- **Report,** domestically or internationally, including under the Paris Agreement's enhanced transparency framework, on the impacts of policies achieved to date.
- **Meet funder requirements** to report on impacts of policies, if applicable.

Users should identify the intended audience(s) of the assessment report. Possible audiences include policymakers, the general public, non-governmental organizations, companies, funders, financial institutions, analysts, research institutions, or other stakeholders affected by (or who can influence) the policy. For more information on identifying stakeholders, refer to the ICAT *Stakeholder Participation Guide* (Chapter 5).

Subsequent chapters provide flexibility to enable users to choose how best to assess the impacts of pricing policies in the context of their objectives, including which impacts to include in the GHG assessment boundary, and which methods and data sources to use. The appropriate level of accuracy and completeness is likely to vary by objective. Users should assess the impacts of pricing policies with a sufficient level of accuracy and completeness to meet the stated objectives of the assessment.

3 Overview of transport pricing policies

Three recently adopted major international agreements outline a collective strategy for sustainable development and climate change, and emphasize the urgency of action in the transport sector: the 2030 Agenda for Sustainable Development (2015), the Paris Agreement (2015) and the New Urban Agenda (2016). To meet the target in the Paris Agreement to limit temperature increase to 1.5–2°C above pre-industrial levels, the goal of the transport sector is to reduce emissions from 7.7 Gt per year to 2–3 Gt per year by 2050. The greater goal is decarbonization and transition to a "net zero emission" economy, where emissions are reduced to a minimum and remaining emissions from specific sectors are sequestered by other means.[10]

3.1 Pricing policies

Because they provide benefits in addition to GHG emissions reductions, transport system changes can be considered win–win GHG emissions reduction solutions. Policies that provide sustainable development benefits can be justified even where they have relatively high costs per unit of emissions reduction. For example, high-quality public transit systems have high costs and low direct emissions reductions. But public transit provides other environmental, social and economic benefits, including reduced vehicle ownership and more compact urban development. On the other hand, some policies, such as fuel efficiency mandates and subsidies for alternative fuels, can have "rebound effects". Rebound effects entail increased consumption as a result of increased efficiency and reduced consumer costs. Certain policies may increase total vehicle travel, and therefore external costs such as traffic and parking congestion, roadway infrastructure costs, accidents and sprawl.

In this methodology, the term "price" refers to the direct financial cost of using a good. Various price changes can affect the mode and frequency of travel, and consequent fuel consumption and GHG emissions. In many countries, current prices often fail to reflect the marginal costs of transport activities, which is economically inefficient and unfair. For example, most roads and parking facilities are unpriced – motorists use them on a first-come, first-served basis, which leads to traffic and parking congestion, and urban vehicle travel beyond what is economically optimal.

Similarly, vehicle insurance and registration fees are generally fixed costs. Motorists pay the same amount regardless of how many kilometres they drive each year. This tends to overcharge owners of vehicles that have lower annual kilometres and undercharge vehicles that have higher annual kilometres, relative to the crash and roadway costs they result in. In addition, current prices often do not reflect external costs such as the health costs of air pollution or traffic accidents. Many of the policies covered in this methodology are therefore justified on basic economic and social equity principles (i.e. marginal-cost pricing and polluter pays), considering the factors discussed in Sections 3.1.2 and 3.1.4.

3.1.1 Influence on travel and fuel consumption

Pricing policies vary in their travel impacts. When evaluating how a pricing policy affects travel and fuel consumption, it is useful to consider how travellers actually perceive a price change. For example, a fuel price increase encourages motorists to drive less, to drive more efficiently (i.e. accelerating more smoothly and reducing speeds), and to choose more fuel-efficient vehicles or alternative-fuel vehicles, when possible. A high vehicle fee, such as a distance-based registration fee or purchase tax, may encourage some households to reduce their vehicle ownership or purchase a lower-fee vehicle. High parking fees, in city centres and other locations, have been found to cause people to change how they travel (e.g. cycling, ride sharing, using public transit instead of driving), where they travel (e.g. from a city centre to other destinations with cheaper parking) or where they park (e.g. to the fringe of the city centre where parking is cheaper), or to find ways to circumvent the fees

[10] Huizenga and Peet (2017).

(e.g. parking illegally).[11] These factors are important considerations when evaluating a pricing policy's costs and benefits.

Motor vehicles tend to have high fixed and low variable costs. This means that, even though automobiles are expensive to own, they are relatively inexpensive to use. A typical car costs several thousand dollars annually in fixed expenses (e.g. depreciation, financing, insurance, registration fees, maintenance, residential parking), but only about $0.20[12] per kilometre in variable expenses (e.g. fuel, tyre wear). Adding a daily parking fee or road toll of $2.00 represents a relatively small increase in total vehicle costs, but doubles the variable costs for a commuter with a 10 kilometre round trip to work. Similarly, the impacts of an increase in a transit fare depend on a traveller's travel mode, trip distances and income.

3.1.2 Factors to consider when planning and evaluating price changes

The impacts of pricing policies depend on how they are structured and how revenues are used. Pricing policies are more effective in reducing GHG emissions where revenues are used to improve low-carbon travel, such as through expanded pedestrian and cycling infrastructure or public transit services. Where revenues are used to improve affordable travel options (e.g. walking, cycling, public transit) or used in other ways that benefit the poor (e.g. bus rapid transit systems funded by local fuel taxes or parking fees), pricing policies can be more effective in achieving social equity objectives.

The impacts of these policies depend on markets, which change over time. For example, when choosing which vehicles to purchase, potential buyers may respond to fuel price increases by purchasing more fuel-efficient and alternative-fuel vehicles, or by choosing more city-accessible homes that require less driving. In general, long-run elasticities are about 3 times as large as short-run elasticities. For example, where a fuel tax increase causes a 10% reduction in fuel consumption in the first year, it should provide a 30% reduction over the long run (more than five years) if maintained in magnitude, accounting for inflation.[13] Travellers take higher prices into account when making durable decisions such as where to live and how many vehicles to own. For example, a household is more likely to decide to commute by transit and reduce its vehicle ownership after fuel prices have remained high for an extended period.

To maximize economic efficiency and minimize welfare losses, price changes are most effective when they are gradual and predictable, allowing the public to anticipate the impacts of the changes when making long-term decisions. The availability of alternative travel options greatly amplifies the impacts of pricing policies.

Many pricing policies have rebound effects, where an increase in energy efficiency stimulates more vehicle travel, which offsets some of the potential GHG emissions reductions or energy savings. The price elasticities in this methodology are based on empirically determined elasticities, and therefore do (to some extent) include rebound effects. It is important to keep in mind that such effects occur and can affect estimated GHG impacts of a policy.

3.1.3 List of pricing policies

Table 3.1 gives an overview of pricing policies in the transport sector, and their vehicle travel and emission impacts. The methodology is not applicable to every policy in this overview table. It is applicable to fuel subsidy reduction or removal, increased fuel tax or levy, road pricing policies and vehicle purchase incentives for more efficient vehicles, as explained in Chapter 1. For more detailed information on each of these policies, see Chapter 10 and Appendix C.

[11] Litman (2016).

[12] Examples provided throughout the methodology use US dollars as the currency, but are not specific to the United States. The given values are rough estimates that are not valid for every country.

[13] For more information on elasticities, see Appendix B for a list of literature.

TABLE **3.1**

Overview of pricing policies

Policy	Description	Vehicle travel and emissions impacts
Reduced fuel subsidies	Removal or reduction of subsidies that reduce the price of vehicle fuel below its fair-market cost. Fuel can be considered highly subsidized if it is priced below international crude oil prices, and moderately subsidized if it is priced below fuel production and roadway costs.	• Increased fuel prices may lead to reduced vehicle travel and/or increased switching to more fuel-efficient and alternative-fuel vehicles.
Increased fuel tax/levy	Increased taxes may include general taxes that apply to many goods and special taxes specific to vehicle fuel.	• Increased fuel prices lead to reduced vehicle travel and/or increased purchase of more fuel-efficient and alternative-fuel vehicles.
Carbon taxes	Carbon taxes are based on a fuel's carbon content, and are therefore a tax on CO_2 emissions.	• By increasing fuel prices, with greater increases for more carbon-intensive fuels such as gasoline, carbon taxes lead to reduced vehicle travel and/or increased purchase of more fuel-efficient and alternative-fuel vehicles.
Increased vehicle tax/levy	Fees on motor vehicle purchases and ownership, including high fees (to ration or reduce vehicle ownership); high import duties on vehicles; and vehicle taxes and fees that increase with vehicle weight, engine size or fuel intensity	• Very high vehicle ownership fees lead to reduced total vehicle ownership. • High duties on imported vehicles may encourage motorists to retain older and less efficient vehicles. • Taxes and fees that vary by vehicle weight, engine size or fuel intensity can encourage motorists to purchase smaller and more efficient vehicles. • Taxes and fees that vary by fuel type or that subsidize vehicles that use low-carbon fuels can encourage motorists to choose lower-carbon-fuelled vehicles.
Road pricing (road tolls and congestion pricing)	Motorists pay directly for driving on a particular roadway in a particular area. Road pricing has two general objectives: revenue generation and congestion management.	• Tolls reduce vehicle travel on affected roadways. • Congestion pricing reduces vehicle travel under congested conditions. • Overall impacts are modest because they only apply to a minor portion of total vehicle travel.
More efficient parking pricing	Parking charges for motorists, and "cash out" parking so that non-drivers receive comparable benefits	• Various impacts, depending on conditions, including reduced vehicle ownership, modal shift, shift of destinations, shift in parking locations and shift to illegal parking
Distance-based vehicle insurance and registration fees	Vehicle charges are based on the amount a vehicle is driven during a time period. This includes pay-as-you-drive vehicle insurance, distance-based registration fees, distance-based vehicle purchase taxes, distance-based vehicle lease fees, weight–distance fees and distance-based emissions fees.	• Various impacts, depending significantly on the policy and its conditions

TABLE **3.1,** continued

Overview of pricing policies

Policy	Description	Vehicle travel and emissions impacts
Public transit fare reforms	Fare reforms include reduced fares, free transfers, universal transit passes and more convenient payment systems (e.g. passes, electronic payment cards, mobile telephone payment systems).	• Most transit travel has low price elasticities, but certain policies have relatively large impacts on travel (e.g. universal transit passes, which can significantly increase transit travel).
Company car tax reforms	Reduced tax structures that encourage employers to subsidize employees' car travel	• Reduced total vehicle travel and emissions, but reforms may also increase the purchase of diesel vehicles
Smart Growth pricing reforms	Higher fees are charged for sprawled development, reflecting the higher costs of providing public infrastructure and services to more dispersed locations.	• Implementation of traffic, parking and stormwater management systems that reduce infrastructure burdens, resulting in more accessible communities where residents drive less

3.1.4 Addressing social equity concerns

Pricing reforms are often criticized as regressive because they are believed to place a larger tax burden on lower-income populations than on higher-income populations. However, this is not necessarily the case. This perception is based on an understanding that a given tax or fee represents a greater portion of income for a lower-income than a higher-income household, which would make the reform regressive. However, this is only the case where all households purchase the same transport-related goods and services. Lower-income households have been shown to drive less and use less fuel than higher-income households. There are two general ways to evaluate pricing equity:

- **Horizontal equity** assumes that public policies should not favour one group over others, which implies that people should "get what they pay for and pay for what they get" unless subsidies are specifically justified. By this measure, transport pricing tends to increase fairness and social equity, since it charges motorists directly for the roads, parking, accident risk, pollution and other costs they impose on other people.

- **Vertical equity** assumes that public policies should favour physically, economically or socially disadvantaged groups over more advantaged groups – for example, through "progressive" price structures that charge disadvantaged people less. Although transport price increases often seem regressive, since a given tax or fee represents a larger portion of income for lower-income than higher-income households, they are generally less regressive than other transport funding options, such as using general taxes to pay for roads, or incorporating parking facility costs into building rents. Since motor vehicle travel tends to increase with income, the distribution of road, parking and fuel subsidies tends to be regressive – that is, lower-income people receive far smaller subsidies than higher-income people.

Some subsidies are hidden and indirect, and careful analysis is needed to understand their equity impacts. For example, some countries subsidize vehicle fuel sales in various ways, and others apply low fuel taxes, which are a hidden subsidy for driving. In such cases, it is necessary to calculate the total amounts of subsidy and under-taxing, analyse how these savings are distributed by income class, and estimate the tax reductions or additional public benefits that these subsidies could provide if redirected to lower-income households.

Transport pricing can be very progressive (i.e. significantly benefiting disadvantaged people) if:

- it includes needs-based subsidies or discounts, so that disadvantaged people pay less than advantaged people
- revenues are used in ways that benefit disadvantaged groups – for example, to support inclusive and affordable transport options (walking, cycling, public transit and universal design features)
- it reduces more regressive taxes such as property and sales taxes.

Other public policies can help achieve transport equity – for example, by developing affordable housing in accessible urban locations so that physically and economically disadvantaged residents can walk or bicycle to local services and jobs, rather than needing to pay public transit fares.

3.1.5 Elements of successful pricing policies in the transport sector

Several common elements of transport pricing policies have proven effective in reducing GHG emissions, achieving sustainable development benefits and addressing social equity concerns. Pricing policies have proven most effective where policymakers:

- account comprehensively for all significant sustainable development impacts and rebound effects so that all stakeholders understand the full benefits that result
- address social equity concerns by using revenues in ways that benefit disadvantaged groups, including investments in affordable transport modes. In some cases, disadvantaged groups may receive direct subsidies, exemptions, discounts or rebates
- implement pricing policies as an integrated package with complementary and reinforcing transport and land-use emissions reduction strategies (e.g. improving low-carbon travel modes), and Smart Growth policies that support more compact urban development
- implement pricing policies predictably and gradually, using comprehensive stakeholder consultations to improve them, increase their acceptance and incorporate inflation factors.

Generally, fuel price increases at the national level may have a large GHG mitigation impact, but may also face strong political opposition. While planning for and assessing pricing policies, it is important to account for the earmarking of revenues, which may significantly influence the mitigation impact.

3.2 A national system for tracking the transport sector

Countries implement monitoring, reporting and verification (MRV) systems in the transport sector to support and improve policy planning, implementation and assessment, with the underlying objective of enhancing the environmental, social and economic impacts of policies. This section highlights the importance of transport sector MRV systems that enable policymakers to understand the total national GHG emissions in the transport sector and the impacts of the mitigation actions being implemented. For more information on, and examples of, MRV systems, see the *Reference Document on Measurement, Reporting and Verification in the Transport Sector.*

3.2.1 Building and strengthening a national-level MRV system for the transport sector

The specific nature of an MRV system depends on whether countries have committed to an economy-wide target, a sector-wide mitigation target or individual mitigation policies. Whereas a full inventory of GHG emissions is needed to assess a sectoral mitigation target, assessment of a specific mitigation policy involves estimating GHG emissions reductions within the GHG assessment boundary against a baseline scenario.

Transport GHG emissions can be quantified using two types of data: energy use (top-down) and travel activity (bottom-up). Bottom-up data allow users to quantify and monitor emissions resulting from a policy in much more detail. Where possible, these two approaches should be aligned, since consistency is necessary for many steps undertaken in the assessment.

The transport sector involves a diverse array of interconnected activities, including policies that directly and indirectly affect one or more components. As a result, GHG emissions are dependent on the level of travel activity (A), the modal structure (S), the fuel intensity of each mode (I) and the fuel’s carbon content, which determines the emission factor (F) that is used. The relationship between these parameters is represented by the "ASIF" equation or "ASIF framework". The ASIF framework used in the bottom-up approach establishes a connection between mitigation actions and GHG emissions, and helps users identify transport indicators for the assessment. For more information on the ASIF framework, see the *Reference Document on Measurement, Reporting and Verification in the Transport Sector.*

When building or strengthening a national MRV system, it is important to consider national circumstances and capacity. When defining the type of data necessary to track policies, it is important to identify what data are needed; how data will be processed; and the entities responsible for data collection, analysis and monitoring. To the extent possible, countries should use existing domestic arrangements, processes and systems for data collection and management. Countries should establish new institutions where they are lacking.

3.2.2 Benefits of a robust national MRV system

A robust national transport MRV system has multiple benefits beyond the tracking of GHG emissions reductions. A robust system supports policymakers and stakeholders in decision-making by allowing them to:

- identify national sectoral priorities and improve transport planning at the national and subnational levels
- assess progress on transport policies being implemented and identify where to focus new GHG emission reduction efforts
- understand and evaluate the effectiveness of transport policies in achieving GHG emissions reductions and sustainable development objectives
- improve efficiency by reducing redundancy in data collection and processing, by establishing clear roles and responsibilities
- ensure transparency, accuracy and comparability of information
- assist different institutions with domestic and international reporting to the United Nations Framework Convention on Climate Change (UNFCCC)
- communicate to donors on achievements made possible through their funding
- attract additional public and private finance.

3.2.3 Institutional setting for robust transport sector data

The institutional setting is a key component of a successful MRV system. Information on key performance indicators and parameters can be dispersed among a number of institutions. Given the wide variety of data needed for impact assessment and the number of different stakeholders involved, strong institutional arrangements serve an important function. Institutions play a central role in collecting, processing and reporting relevant data. Strong institutional arrangements need to be backed up by a legal framework (a law, regulation or decree) to ensure that key actors are empowered to perform their functions.

The institutional arrangements that are required depend on the scope of the MRV and whether it relates to national or subnational actions (e.g. cities). Countries may already have institutional arrangements in place to conduct these activities. Where this is the case, they can consider expanding their MRV system to monitor the impact of pricing policies.

A technical coordinator, or coordinating team or body is often assigned to lead MRV processes in which responsibilities have been delegated to different institutions. Since data can be widely dispersed between these institutions, the coordinating body oversees the procedures for data collection, management and reporting. The coordinating body may also oversee technical and institutional capacity-building, and monitor quality control and quality assurance standards with other participating institutions. This collaboration aims to maximize synergies, enhance efficiency and streamline the work between the institutions involved.

Users may find it helpful to identify, inform and consult stakeholders when setting up the coordination team and planning the assessment. Refer to the ICAT *Stakeholder Participation Guide* for guidance on identifying and understanding stakeholders (Chapter 5), forming multi-stakeholder bodies (Chapter 6), providing information to stakeholders (Chapter 7), designing and conducting consultations (Chapter 8), and engaging in general with stakeholders throughout the entire impact assessment process.

The establishment of a data clearing house, or a virtual repository that collects and stores data, has proven useful for data management in several countries. In many cases, the clearing house is integrated into the country's statistical bureau.

Where strong institutional arrangements do not yet exist, countries can identify and strengthen a governmental body to ensure that it has adequate capacity and authority to be responsible for the MRV system and establish appropriate legal arrangements. Institutional mandates help to strengthen the procedures and the system, and may also help secure funding from the government to ensure the continuity of the process. Users can refer to the UNFCCC *Toolkit for Non-Annex I Parties on Establishing and Maintaining Institutional Arrangements for Preparing National Communications and Biennial Update Reports*,[14] as well as Table 6 in the *Reference Document on Measurement, Reporting and Verification in the Transport Sector*, for support on establishing or improving the institutional arrangements for a robust MRV system.

[14] Available at: http://unfccc.int/files/national_reports/non-annex_i_natcom/training_material/methodological_documents/application/pdf/unfccc_mda-toolkit_131108_ly.pdf.

4 Using the methodology

This chapter provides an overview of the steps involved in assessing the GHG impacts of pricing policies, and outlines assessment principles to help guide the assessment.

Checklist of key recommendations

- Base the assessment on the principles of relevance, completeness, consistency, transparency and accuracy

4.1 Overview of steps

This methodology is organized according to the steps a user follows in assessing the impacts of a pricing policy (see Figure 1.1). Depending on when the methodology is applied and the approach chosen, users can skip certain chapters. When assessing vehicle purchase incentives and road pricing policies, users can skip to Chapter 10 after Chapter 6.

4.2 Planning for the assessment

Users should review this methodology, the *Introduction to the ICAT Assessment Guides* and other relevant assessment guides, and plan the steps, responsibilities and resources needed to meet their objectives for the assessment in advance. This includes identifying the expertise and data needed for each step, planning the roles and responsibilities of different actors, and securing the budget and other resources needed. Any interdependencies between steps should be identified – for example, where outputs from one step feed into another – and timing should be planned accordingly.

The time and human resources required to implement the methodology and carry out an impact assessment depend on a variety of factors, such as the complexity of the policy being assessed, the extent of data collection needed and whether relevant data have already been collected, whether analysis relating to the policy has previously been done, and the level of accuracy and completeness needed to meet the stated objectives of the assessment.

4.2.1 Choosing a desired level of accuracy based on objectives

A range of options exists for assessing GHG impacts that allow users to manage trade-offs between the accuracy of the results, and the resources, time and data needed to complete the assessment, based on objectives. Some objectives require more detailed assessments that yield more accurate results (to demonstrate that a specific reduction in GHG emissions is attributable to a specific policy, with a high level of certainty), whereas other objectives may be achieved with simplified assessments that yield less accurate results (to show that a policy contributes to reducing GHG impacts, but with less certainty around the magnitude of the impact).

Users should choose approaches and methods that are sufficient to accurately meet the stated objectives of the assessment and ensure that the resulting claims are appropriate – for example, whether a policy contributes to achieving GHG emissions reductions or whether emissions reductions can be attributed to the policy. Users should also consider the resources required to obtain the data needed to meet the stated objectives of the assessment.

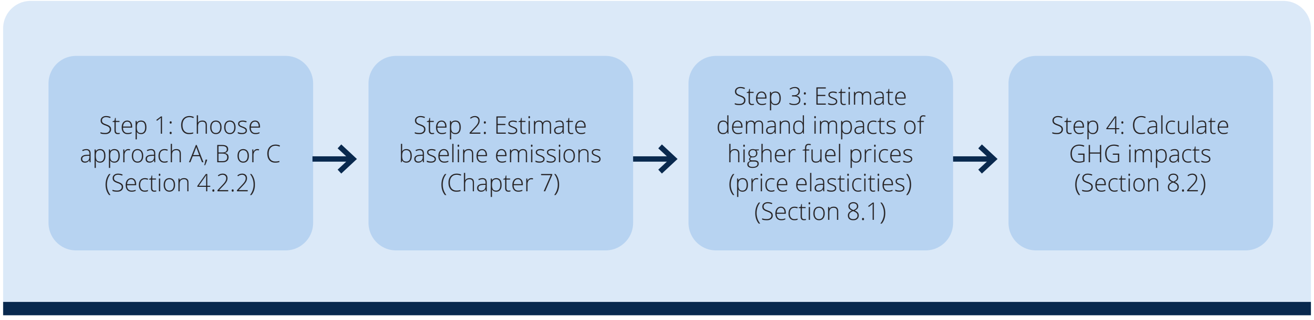
4.2.2 Approaches to GHG impact assessment

The methodology outlines four principal steps for assessing the impacts of a policy, shown in Figure 4.1. Within each principal step are further steps that users follow to calculate GHG impacts.

Step 1 of assessing a policy (choosing the approach for estimating the GHG impacts of the policy) is covered in this section. To assess a vehicle purchase incentive or a road pricing policy, users should proceed directly to Chapter 10.

FIGURE **4.1**

Four key steps in assessing the impacts of pricing policies



Chapters 7–9 provide methods for estimating the GHG impacts of pricing policies. Approaches for vehicle purchase incentive and road pricing policies are addressed in Chapter 10. The methodology provides three approaches for users. The choice of approach depends on the level of data available and the expertise of the user:

- **Approach A** estimates the GHG impacts of a pricing policy for the sum of gasoline- and diesel-related emissions from a country's transport sector, and is appropriate for users with an undifferentiated fuel mix (national, subnational or municipal level).
- **Approach B** estimates the GHG impacts separately for gasoline- and diesel-fuelled vehicles for users with a differentiated fuel mix (national, subnational or municipal level).
- **Approach C** is not comparable to approaches A and B. It estimates the GHG impacts for passenger transport separately for passenger cars, and bus- and rail-based public transport for users who have differentiated fuel mix data and data on passenger kilometres (PKM)[15] and tonne kilometres (TKM).[16] In the methodology, freight transport is excluded, to keep the explanations and calculations simple. Users can apply the approach and include freight transport using TKM. However, when GHG impacts are assessed using approach C, as described in this methodology, the results will not reflect the same system boundaries and scope as approaches A and B. Results from approach C provide a higher level of detail.

These approaches focus on gasoline and diesel. The same approaches could be used for other fuels, such as liquefied petroleum gas (LPG) or compressed natural gas (CNG), by using analogous equations with different input data (i.e. travel activity data, emission factors and elasticity values).

The *Reference Document on Measurement, Reporting and Verification in the Transport Sector* (Section 2.1) defines two types of data sets: top-down "energy use" and bottom-up "travel activity" data, as described in Section 3.2.1. Approaches A and B are based on the top-down approach, whereas approach C is based on both the top-down and the bottom-up approaches.

Comparison of the three approaches

The three approaches lead to different results. Moving from approach A to approach C, the level of detail necessary for the assessment increases (e.g. including electric vehicles in the assessment requires much more data), which has an impact on the results. GHG emissions reductions estimated with approach A tend to be higher than with approach B, since approach A does not differentiate between the fuel types, and diesel fuel usually has a lower price elasticity than gasoline.

Approach C is not comparable to approaches A or B because it includes only passenger transport. Additionally, approach C allows the geographical system boundaries to be set for an urban context rather than at the national level. By assessing several urban regions using approach C, larger regions can

15 PKM equals the numbers of passengers multiplied by the kilometres travelled with a specific vehicle (vehicle kilometres). For example, if two people travel in one passenger car for 20 kilometres, this equals 2 people × 20 km = 40 PKM.

16 TKM is based on the same concept as PKM, but for freight and using tonnes as the unit. For example, if 3 t of a good are transported for 20 kilometres in a heavy-duty vehicle, this equals 3 t × 20 km = 60 TKM.

be aggregated and analysed. It is also possible to apply two different approaches (e.g. approach B at the national level and approach C for an urban region) to conduct a national assessment while still gaining valuable insights from approach C on the impacts of mode shift. Through the use of cross-price elasticities, approach C accounts for a decrease in the GHG emissions reductions related to modal shifts, which is not reflected in the results of approaches A or B.

Table 4.1 provides an overview of the differences between approaches A, B and C, and helps users choose the most appropriate approach for their assessment.

4.2.3 Methods for obtaining or estimating data

It is recommended that users use country-specific data. Where country-specific data are not available, default values can be used, such as those provided by the Intergovernmental Panel on Climate Change (IPCC) for emission factors and net calorific values (NCVs). For possible data sources for elasticity values, see Appendix B. Sections 7.2 and 7.3 briefly discuss how to include biofuels (e.g. bioethanol or biodiesel, possibly as proportions of fossil fuels) in the estimation.

For planning purposes, it is helpful for the user to identify the desired approach before beginning an impact assessment. The approach should be selected based on the user's objectives, capacity and resources (see Figure 4.2). If the user's objective is to understand the impact of a policy and use that information to meet a variety of objectives – such as informing policy design, improving policy implementation, evaluating policy effectiveness, reporting on policy impacts, and attracting finance based on policy impacts – users should assess impacts using a more robust approach.

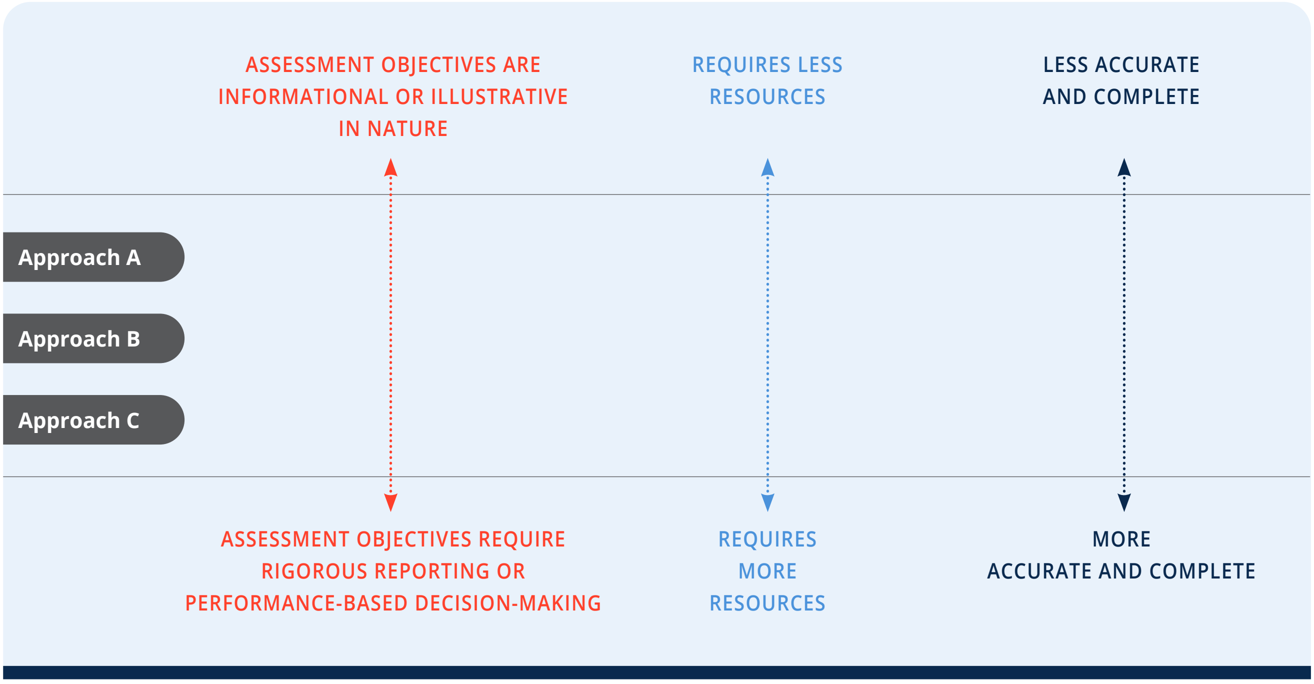
TABLE **4.1**

Overview of approaches covered by the methodology

Approach	Data requirements	Boundaries and coverage		
		Geographical system boundaries	Passenger/freight	Fuel types
A	Only general fuel consumption data (Basis for calculation: top-down energy-use data)	National, subnational or municipal	Ground transport (passenger and freight)	Fuel mix (unspecified mix of gasoline, diesel and/or other transport fuels)
B	Specific gasoline and diesel consumption data (Basis for calculation: top-down energy-use data)	National, subnational or municipal	Ground transport (passenger and freight)	Gasoline and diesel
C	Comprehensive bottom-up travel activity data (e.g. distance travelled by mode j) (Basis for calculation: top-down energy-use data and bottom-up travel activity data)	Regional, urban	Only passenger transport in an urban context However, the assessment can be conducted for several (large) cities to enable a more extensive geographical coverage	Gasoline, diesel and electricity

FIGURE **4.2**

Range of approaches for estimating GHG impacts based on data availability



4.2.4 Expert judgment

It is likely that expert judgment and assumptions will be needed to complete an assessment where information is not available. Expert judgment is defined by the IPCC as a "carefully considered, well-documented qualitative or quantitative judgment made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field".[17] The goal is to be as representative as possible to reduce bias and increase accuracy. The user can apply their own expert judgment or consult experts.

When relying on expert judgment, information can be obtained through methods that are known as expert elicitation. The *2006 IPCC Guidelines for National Greenhouse Gas Inventories* provides a procedure for expert elicitation, including a process for helping experts understand the elicitation process, avoiding biases, and producing independent and reliable judgments.[18]

Expert judgment can be associated with a high level of uncertainty. As such, experts can be consulted to provide a range of possible values and the related uncertainty range, or to help select suitable values from a range of values. Expert judgment can be informed or supported by broader consultations with stakeholders.

It is important to document the reason that no data sources are available and the rationale for the value chosen.

4.2.5 Planning stakeholder participation

Stakeholder participation is recommended at many steps throughout the methodology. It can strengthen the impact assessment and the contribution of policies to GHG emissions reduction goals in many ways, including by:

- establishing a mechanism through which people who may be affected by, or can influence, a policy have an opportunity to raise issues and have these issues considered before, during and after policy implementation

[17] IPCC (2000).

[18] IPCC (2006).

- raising awareness and enabling better understanding of complex issues for all parties involved, thereby building their capacity to contribute effectively
- building trust, collaboration, shared ownership and support for policies among stakeholder groups, leading to less conflict and easier implementation
- addressing stakeholder perceptions of risks and impacts, and helping to develop measures to reduce negative impacts and increase benefits for all stakeholder groups, including the most vulnerable
- increasing the credibility, accuracy and comprehensiveness of the assessment by drawing on diverse expert, local and traditional knowledge and practices – for example, to provide inputs on data sources, methods and assumptions
- increasing transparency, accountability, legitimacy and respect for stakeholders' rights
- enabling enhanced ambition and financing by strengthening the effectiveness of policies and the credibility of reporting.

Various sections throughout this methodology explain where stakeholder participation is recommended – for example, in identifying a complete list of GHG impacts (Chapter 6), estimating baseline emissions (Chapter 7), estimating GHG impacts (Chapter 10), monitoring performance over time (Chapter 11) and reporting (Chapter 12).

Before beginning the assessment process, users should consider how stakeholder participation can support the objectives, and include relevant activities and associated resources in their assessment plans. It may be helpful to combine stakeholder participation for impact assessment with other participatory processes involving similar stakeholders for the same or related policies, such as those being conducted for assessment of sustainable development and transformational impacts, and for technical review.

It is important to ensure conformity with national legal requirements and norms for stakeholder participation in public policies. Requirements of specific donors, and of international treaties, conventions and other instruments that the country is party to should also be met. These are likely to include requirements for disclosure, impact assessments and consultations. They may include specific requirements for certain stakeholder groups (e.g. United Nations Declaration on the Rights of Indigenous Peoples, International Labour Organization Convention 169).

During the planning phase, it is recommended that users identify stakeholder groups that may be affected by, or may influence, the policy. Appropriate approaches should be identified to engage with stakeholder groups, including through their legitimate representatives. Effective stakeholder participation could be facilitated by establishing a multi-stakeholder working group or advisory body consisting of stakeholders and experts with relevant and diverse knowledge and experience. Such a group may provide advice and potentially contribute to decision-making; this will ensure that stakeholder interests are reflected in design, implementation and assessment of policies.

Refer to the ICAT *Stakeholder Participation Guide* for more information, such as how to plan effective stakeholder participation (Chapter 4), identify and analyse different stakeholder groups (Chapter 5), establish multi-stakeholder bodies (Chapter 6), provide information (Chapter 7), design and conduct consultations (Chapter 8), and establish grievance redress mechanisms (Chapter 9). Appendix G of this document summarizes the steps in this methodology where stakeholder participation is recommended and provides specific references to relevant guidance in the *Stakeholder Participation Guide*.

4.2.6 Planning technical review (if relevant)

Before beginning the assessment process, users should consider whether technical review of the assessment report will be pursued. The technical review process emphasizes learning and continual improvement, and can help users identify areas for improving future impact assessments. Technical review can also provide confidence that the impacts of policies have been estimated and reported according to ICAT key recommendations. Refer to the ICAT *Technical Review Guide* for more information on the technical review process.

4.3 Assessment principles

Assessment principles underpin and guide the impact assessment process, especially where the methodology provides flexibility. It is a *key recommendation* to base the assessment on the principles of relevance, completeness, consistency, transparency and accuracy, as follows:[19]

- **Relevance.** Ensure that the assessment appropriately reflects the GHG impacts of the policy and serves the decision-making needs of users and stakeholders – both internal and external to the reporting entity. Applying the principle of relevance depends on the objectives of the assessment, broader policy objectives, national circumstances and stakeholder priorities.

- **Completeness.** Include all significant impacts – both positive and negative – in the GHG assessment boundary. Disclose and justify any specific exclusions.

- **Consistency.** Use consistent assessment approaches, data-collection methods and calculation methods to allow meaningful performance tracking over time. Document any changes to the data sources, GHG assessment boundary, methods or any other relevant factors in the time series.

- **Transparency.** Provide clear and complete information for stakeholders to assess the credibility and reliability of the results. Disclose and document all relevant methods, data sources, calculations, assumptions and uncertainties. Disclose the processes, procedures and limitations of the assessment in a clear, factual, neutral and understandable manner with clear documentation. The information should be sufficient to enable a party external to the assessment process to derive the same results if provided with the same source data. Chapter 12 provides a list of recommended information to report to ensure transparency.

- **Accuracy.** Ensure that the estimated impacts are systematically neither over nor under actual values, as far as can be judged, and that uncertainties are reduced as far as practicable. Achieve sufficient accuracy to enable users and stakeholders to make appropriate and informed decisions with reasonable confidence about the integrity of the reported information. If accurate data for a given impact category are not currently available, users should strive to improve accuracy over time as better data become available. Accuracy should be pursued as far as possible, but, once uncertainty can no longer be practically reduced, conservative estimates should be used. Box 4.1 provides guidance on conservativeness.

In addition to the principles above, users should follow the principle of comparability if it is relevant to the assessment objectives – for example, if the objective is to compare multiple policies based on their GHG impacts, or to aggregate the results of multiple impact assessments and compare the collective impacts with national goals (discussed further in Box 4.2).

- **Comparability.** Ensure common methodologies, data sources, assumptions and reporting formats, such that the estimated impacts of multiple policies can be compared.

In practice, users may encounter trade-offs between principles when developing an assessment. For example, a user may find that achieving the most complete assessment requires using less accurate data for a portion of the assessment, which could compromise overall accuracy. Users should balance trade-offs between principles depending on their objectives. Over time, as the accuracy and completeness of data increase, the trade-off between these principles will likely diminish.

BOX **4.1**

Conservativeness

Conservative values and assumptions are more likely to overestimate negative impacts or underestimate positive impacts resulting from a policy. Users should consider conservativeness in addition to accuracy when uncertainty can no longer be practically reduced, when a range of possible values or probabilities exists (e.g. when developing baseline scenarios), or when uncertainty is high.

Whether to use conservative estimates and how conservative to be depends on the objectives and the intended use of the results. For some objectives, accuracy should be prioritized over conservativeness, to obtain unbiased results. The principle of relevance can help guide what approach to use and how conservative to be.

[19] Adapted from WRI (2014).

BOX **4.2**

Applying the principle of comparability when comparing or aggregating results

Users may want to compare the estimated impacts of multiple policies – for example, to determine which policy has the greatest positive impacts. Valid comparisons require that assessments have followed a consistent methodology – for example, regarding the assessment period, the types of impact categories, impacts and indicators included in the GHG assessment boundary, baseline assumptions, calculation methods, and data sources. Users should exercise caution when comparing the results of multiple assessments, since differences in reported impacts may be a result of differences in methodology rather than real-world differences. To understand whether comparisons are valid, all methods, assumptions and data sources used should be transparently reported. Comparability can be more easily achieved if a single person or organization assesses and compares multiple policies using the same methodology.

Users may also want to aggregate the impacts of multiple policies – for example, to compare the collective impact of multiple policies in relation to a national goal. Users should likewise exercise caution when aggregating the results if different methods have been used and if there are potential overlaps or interactions between the policies being aggregated. In such a case, the sum would either overestimate or underestimate the impacts resulting from the combination of policies. For example, the combined impact of a national fuel pricing policy and a national policy promoting electric vehicles in the same country will probably be less than the sum of the impacts of the two policies when assessed separately, since they affect the same activities. Chapter 5 provides more information on policy interactions.

PART II

Defining the assessment

5 Describing the pricing policy

This chapter provides guidance on describing the policy. To estimate the GHG impacts of a policy, users need to describe the policy that will be assessed, decide whether to assess the individual policy or a package of related policies, and choose whether to carry out an ex-ante or ex-post assessment.

Checklist of key recommendations

- Clearly describe the policy (or package of policies) that is being assessed

5.1 Describe the policy to be assessed

To effectively carry out an impact assessment (in subsequent chapters), a detailed understanding of the policy being assessed is needed. It is a *key recommendation* to clearly describe the policy (or package of policies) that is being assessed. Table 5.1 provides a checklist of recommended information that should be included in a description to enable an effective assessment. Table 5.2 outlines additional information that may be relevant, depending on the context.

If assessing a package of policies, these tables can be used to document either the package as a whole or each policy in the package separately. The first two steps in the chapter (Sections 5.1 and 5.2) can be done together or iteratively.

Users who are assessing the sustainable development and/or transformational impacts of the policy (using the ICAT *Sustainable Development Methodology* and/or *Transformational Change Methodology*) should describe the policy in the same way to ensure a consistent and integrated assessment.

5.2 Decide whether to assess an individual policy or a package of policies

Where multiple policies are being developed or implemented in the same time frame, users can assess them either individually or as a package. When making this decision, users should consider the assessment objectives, the feasibility of assessing impacts individually or as a package, and the degree of interaction between the policies.

Pricing policies may interact with other policies and actions. For example, higher fuel prices can be implemented along with other pricing policies, to further reduce emissions from the transport sector. Chapter 10 provides additional guidance to help users estimate the impacts of purchase incentives for highly efficient vehicles and road pricing policies. If several pricing measures are implemented together, users can assess a package of policies. More guidance on policy interactions and whether to assess an individual policy or a package of policies

FIGURE **5.1**

Overview of steps in the chapter

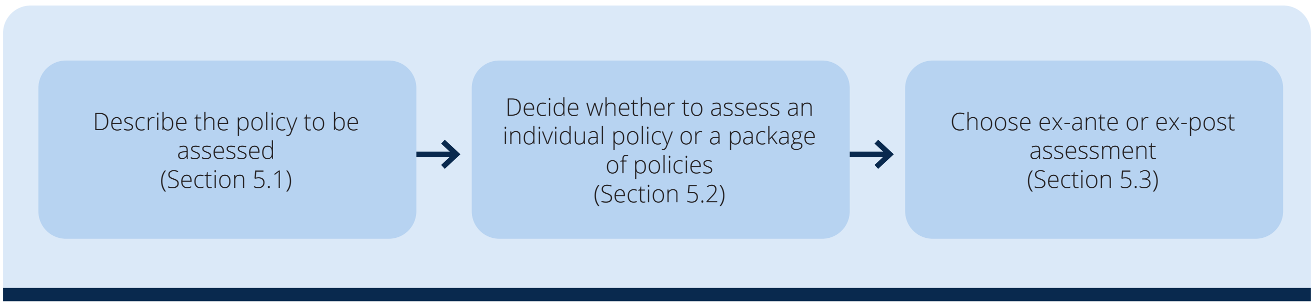


TABLE **5.1**

Checklist of recommended information to describe the policy being assessed

Information	Description	Examples
Title of the policy	Policy name	National Fuel Levy
Type of policy	The type of policy, such as those presented in Table 3.1.	Increased fuel tax/levy
Description of specific interventions	The specific intervention(s) carried out as part of the policy, such as the technologies, processes or practices implemented	The national fuel levy is on gasoline and diesel. It will target LDVs in the form of a fixed sum per litre – higher for gasoline than for diesel. Mean average income of $13,254 per capita and an annual mean fuel price of $0.75 per litre in 2016. Elasticities are as follows: • Default gasoline own-price elasticity value is –0.24. • Default diesel price elasticity value is –0.22. • Cross-price elasticity with respect to gasoline price, for motor bus, is 0.15. • Cross-price elasticity with respect to gasoline price, for rail (average), is 0.24.
Status of policy	Whether the policy is planned, adopted or implemented	Planned
Date of implementation	The date the policy comes into effect (not the date that any supporting legislation is enacted)	1 January 2017
Date of completion (if applicable)	If applicable, the date the policy ceases, such as the date a tax is no longer levied or the end date of an incentive scheme with a limited duration (not the date that the policy no longer has an impact)	2022
Implementing entity or entities	The entity or entities that implement(s) the policy, including the role of various local, subnational, national, international or any other entities	Ministry of Finance
Objectives and intended impacts or benefits of the policy	The intended impact(s) or benefit(s) of the policy (e.g. the purpose stated in the legislation or regulation)	High-level objectives: • To encourage individuals and industry to use less fossil fuel and to reduce GHG emissions • To send a consistent price signal • To ensure that emitters pay for emissions (integrating external costs) • To encourage a shift to more efficient vehicles and/or more efficient modes of transport
Level of the policy	The level of implementation, such as national level, subnational level, city level, sector level or project level	National

TABLE **5.1,** continued

Checklist of recommended information to describe the policy being assessed

Information	Description	Examples
Geographic coverage	The jurisdiction or geographic area where the policy is implemented or enforced, which may be more limited than all the jurisdictions where the policy has an impact	Country
Sectors targeted	Which sectors or subsectors are targeted	Gasoline and diesel emissions from passenger transport vehicles and LDVs
Greenhouse gases targeted	Which GHG the policy aims to control, which may be more limited than the set of GHGs that the policy affects	CO_2
Other related policies or actions	Other policies or actions that may interact with the policy being assessed	A policy titled Transport 2030 aims to plan regional transport systems across municipal borders, increasing ease of access to public transport. Public transport will also be subsidized through this policy in rural areas.

Source: Adapted from WRI (2014).
Abbreviations: CO_2, carbon dioxide; LDV, light-duty vehicle

TABLE **5.2**

Checklist of additional information that may be relevant to describe the policy being assessed

Information	Description	Examples
Intended level of mitigation to be achieved and/or target level of other indicators	Target level of key indicators, if applicable	Target • 3–5% annual reductions in vehicle emissions compared with baseline • $X revenue generated
Title of establishing legislation, regulations or other founding documents	The name(s) of legislation or regulations authorizing or establishing the policy (or other founding documents, if there is no legislative basis)	Motor Fuel Levy Law
Monitoring, reporting and verification procedures	References to any MRV procedures associated with implementing the policy	A data clearing house will be established, and a coordinating body will oversee and monitor quality control/quality assurance standards with other participating institutions involved in data collection.
Enforcement mechanisms	Any enforcement or compliance procedures, such as penalties for non-compliance	Enforcement mechanisms may be necessary.

TABLE **5.2,** continued

Checklist of additional information that may be relevant to describe the policy being assessed

Information	Description	Examples
Reference to relevant documents	Information to allow practitioners and other interested parties to access any guidance documents related to the policy (e.g. through websites)	IPCC guidelines and emission factors, national GHG emissions inventories, national/ international data sources
Broader context or significance of the policy	The broader context for understanding the policy	The policy will contribute to the goal established in the country's NDC to reduce growth of total national GHG emissions in 2030 from 20% to 10% above 2010 levels.
Outline of sustainable development impacts of the policy	Any anticipated sustainable development benefits other than GHG mitigation	Estimation of impact of policy, including use of revenues, on low-income households Will reduce air pollution, congestion and traffic
Key stakeholders	Key stakeholder groups affected by the policy	Departments or ministries of transport Ministries of finance National and city governments Public transit authorities Taxation bureaus Fleet operators Vehicle manufacturers Consumers
Other relevant information	Any other relevant information (e.g. costs, non-GHG mitigation benefits)	

Source: Adapted from WRI (2014).

is provided in Chapter 5 of the *Policy and Action Standard*.

Elasticities are empirical values and implicitly take other policies into consideration; where other policies have an impact on behaviours, such impacts are represented in the elasticity.

In subsequent chapters, users follow the same general steps and requirements, whether they choose to assess an individual policy or a package of policies. Depending on the choice, the impacts assessed in later chapters will apply either to the individual policy or to the package of policies.

5.3 Choose ex-ante or ex-post assessment

After describing the policy or package of policies being assessed, decide whether to carry out an ex-ante assessment (see Chapter 8), an ex-post assessment (see Chapter 9), or a combined ex-ante and ex-post assessment. Choosing between ex-ante or ex-post assessment depends on the status of the policy. Where the policy is planned or adopted, but not yet implemented, the assessment will be ex-ante by definition. Once the policy has been implemented, the assessment can be ex-ante, ex-post, or a combined ex-ante and ex-post assessment. The assessment is an ex-post assessment if the objective is to estimate the impacts of the policy to date, an ex-ante assessment if the objective is to estimate the expected impacts in the future, and a combined ex-ante and ex-post assessment if the objective is to estimate both the past and future impacts.

In practice, assessment of pricing policies is primarily ex-ante. An ex-ante assessment helps the user determine whether to implement the policy, and is also important in determining the level of price increase and coverage. Ex-post assessment is an important complement to ex-ante assessment, although it is not often undertaken because of its complexity, and the data and modelling skills required.

The assessment of pricing policies on the basis of price elasticities is fundamentally different. After the policy has been implemented, there are so many different factors that influence the emissions from ground transport that the ex-post estimate does not provide a significantly better level of accuracy (see Chapter 8 for a more thorough description of accuracy associated with ex-ante assessments). In other words, the additional data available after implementation of the policy (e.g. actual fuel consumption) do not generally contribute to a much more accurate result than the ex-ante estimation. Therefore, the ex-ante assessment is the key step in assessing impacts of pricing policies, and the ex-post assessment can be used as more of a plausibility check.

6 Identifying impacts: how pricing policies reduce GHG emissions

This chapter provides a process for identifying the most common GHG impacts of transport pricing policies, and guidance for users to identify any additional impacts their policies may have. A list of impacts is provided, as well as a causal chain indicating which impacts are included in the GHG assessment boundary. Guidance is also provided on defining the assessment period. The steps in this chapter are closely interrelated. Users can carry out the steps in sequence or in parallel, and the process may be iterative.

Checklist of key recommendations

- Identify all potential GHG impacts of the policy and associated GHG source categories
- Develop a causal chain
- Include all significant GHG impacts in the GHG assessment boundary
- Define the assessment period

6.1 Identify GHG impacts

GHG impacts are the changes in GHG emissions that result from the policy. For most transport pricing policies being assessed using this methodology, the relevant GHG impacts are likely to be reduced emissions from reduced vehicle travel, shifts to other transport modes and shifts to more fuel-efficient vehicles. Guidance is also provided for identifying GHG impacts of policies where significant impacts arise from the use of revenues.

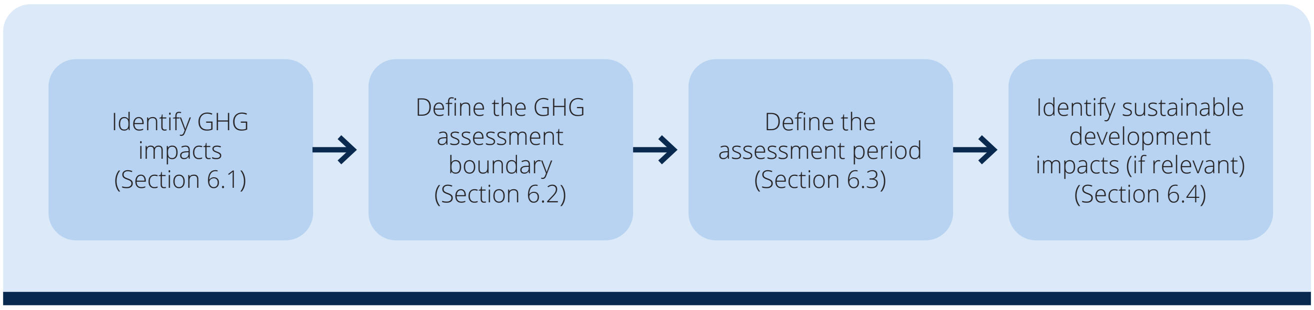
6.1.1 Identify intermediate effects

To identify the GHG impacts of a policy, it is useful to first consider how the policy is implemented by identifying the relevant inputs and activities associated with implementing the policy. Inputs are resources that go into implementing the policy, and activities are administrative activities involved in implementing the policy. These inputs and activities lead to intermediate effects, which are changes in behaviour, technology, processes or practices that result from a policy. Intermediate effects can be categorized by how stakeholders are expected to respond to the policy or to other intermediate effects of the policy, or by the mitigation action or change in behaviour that is mandated or incentivized by the policy. These intermediate effects then lead to the policy's GHG impacts (the reduction in emissions).

Users should identify all intermediate effects that may lead to GHG impacts. The key intermediate effects of an increase in fuel costs are reduced vehicle travel, a shift to other transport modes, and a shift to more fuel-efficient vehicles. The reduction in vehicle travel occurs through two main channels: (1) a reduction in overall vehicle trips, and (2) a modal shift, which contributes to both a reduction in overall vehicle trips and a shift to more efficient transport

FIGURE **6.1**

Overview of steps in the chapter



alternatives. The degree of modal shift depends on the quality of the available substitutes and other factors, including social standing and safety.

The intermediate effects of fuel pricing policies include:

- increased fuel prices
- greater increases in fuel prices for more carbon-intensive fuels, such as gasoline
- reduced vehicle travel
- increased switching to more fuel-efficient and alternative-fuel vehicles
- increased purchase of more fuel-efficient and alternative-fuel vehicles.

6.1.2 Identify potential GHG impacts

It is a *key recommendation* to identify all potential GHG impacts of the policy and associated GHG source categories. Guidance for this is provided below, and further discussion on the process is available in the *Policy and Action Standard*.

The key GHG impacts are the reductions in GHG emissions directly resulting from the identified intermediate effects. Other emission impacts depend on how pricing revenue is used, as discussed below.

Stakeholder consultation can help to ensure the completeness of the list of GHG impacts. Refer to the ICAT *Stakeholder Participation Guide* (Chapter 8) for information on designing and conducting consultations. Relevant stakeholders may include departments or ministries of transport, ministries of finance, national governments, city governments, transportation associations, public transit authorities, energy planning offices, taxation bureaus, the construction industry, the trucking industry, fleet operators, vehicle manufacturers, and consumers.

Users should identify all the GHG source categories associated with the GHG impacts of the policy. Example source categories are provided in Table 6.1.

Importance of how revenues from pricing policies are used

Impacts relating to the use of available revenue generated from the policy cannot be quantified using the calculations in this methodology. However, it is crucial to bear in mind that the use of revenue has a significant influence on GHG impacts (see Appendix D). Users should account for the impacts of the use of revenues by assessing them at least qualitatively and discussing them in the interpretation of their assessment results, as described in Section 8.3.

Increased revenues may be used for different purposes, including:

- use in government spending, which may lead to higher emissions if spent on roadways, for example, rather than infrastructure for public transport, bicycle lanes, and so on

TABLE **6.1**

Example GHG sources for fuel pricing policies

Source category	Description	Emitting entity or equipment	Relevant GHGs
Road transport, LDVs	Fuel combustion from LDVs	Passenger vehicles, light-duty trucks, motorcycles	CO_2
Road transport, HDVs	Fuel combustion from HDVs	Heavy-duty trucks and buses	CO_2
Rail transport	Fuel combustion and electricity use from locomotives	Diesel and electric locomotives	CO_2

Source: Adapted from WRI (2015).

Abbreviations: HDV, heavy-duty vehicle; LDV, light-duty vehicle

- revenue-neutral redistribution to households through
  - lowered taxes, possibly increasing consumer spending and in turn increasing emissions from households
  - targeted subsidies to poor populations to provide a social cushion for subsidy removal
  - equal per capita redistribution
- transport infrastructure, which tends to increase emissions if invested in roadways rather than public transport, bicycle lanes, and so on
- transport efficiency increases (e.g. promoting public transport), which tends to decrease emissions.

For example, several cities primarily use revenue to expand public transport and non-motorized transport facilities. This may reinforce emissions reductions, given that public transport emissions are likely to be relatively small. Many road pricing policies, in contrast, use the revenue to expand roadway capacity, which tends to increase emissions.

Thus, the use of revenues may either further decrease or increase GHG emissions. Revenues may be used to cushion the social burden of removing fuel subsidies – for example, by introducing targeted (e.g. per capita) subsidies for the fraction of the population most impacted by fuel subsidy removal.

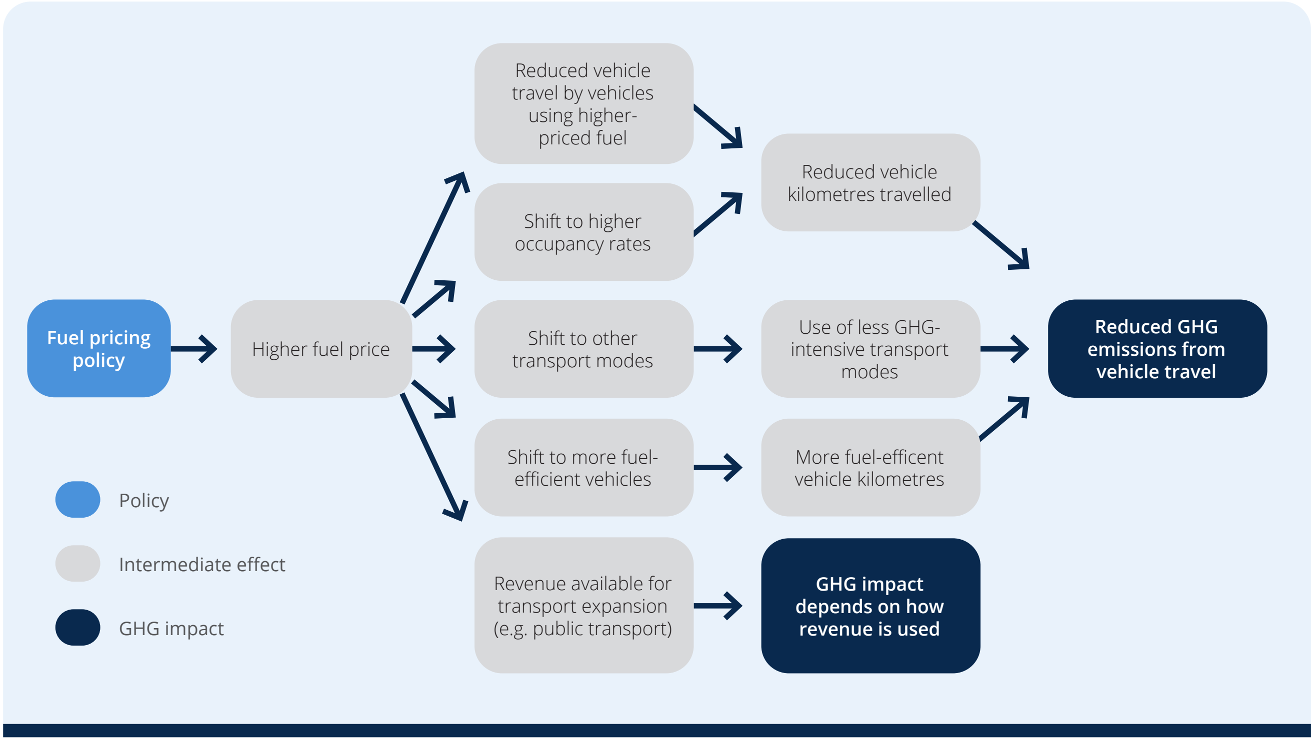
6.1.3 Develop a causal chain

It is a *key recommendation* to develop a causal chain. A causal chain is a conceptual diagram tracing the process by which the policy leads to GHG impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships. Developing a causal chain can help identify effects not previously identified. Figure 6.2 shows a high-level, illustrative example of a causal chain. Causal chains will vary from policy to policy, as will the strength of the links in the causal chain. Users should create their own causal chains, most likely with more (and different) detail from that shown in Figure 6.2.

Consultations with different stakeholder groups affected by, or with influence over, the policy can help with development and validation of the causal chain by integrating stakeholder insights on cause-

FIGURE **6.2**

Example causal chain for fuel pricing policies



and-effect relationships between behaviour changes and expected impacts. Refer to the ICAT *Stakeholder Participation Guide* for information on identifying and understanding stakeholders (Chapter 5), and designing and conducting consultations (Chapter 8).

Where users are also applying the ICAT *Sustainable Development Methodology*, the causal chain can be used as a starting point for a causal chain mapping exercise that includes sustainable development impacts as well as GHG impacts.

6.2 Define the GHG assessment boundary

The GHG assessment boundary defines the scope of the assessment in terms of the range of GHG impacts. It is a *key recommendation* to include all significant GHG impacts in the GHG assessment boundary. The identified GHG impacts and the associated GHG source categories should be categorized for magnitude and likelihood. They should be included in the GHG assessment boundary if they are categorized as moderate or major in magnitude, and very likely, likely or possible in likelihood (i.e. deemed significant). The *Policy and Action Standard* provides further information about categorizing GHG impacts.

For pricing policies, the relevant GHG impacts are reduced GHG emissions from vehicle travel, caused by reduced vehicle kilometres travelled, a shift to less GHG-intensive transport modes, and a shift to more fuel-efficient vehicles. These GHG impacts are included in the assessment boundary because they are categorized as either likely or very likely, and of moderate or major relative magnitude.

Users should note that GHG emissions resulting from the use of revenue may indeed be significant and are therefore included in the GHG assessment boundary. However, these GHG impacts have not been included in the GHG assessment boundary of the methodology. Emissions may increase or decrease depending on how revenue is used (see Section 6.1.2), and users should ensure that they account for these impacts.

Table 6.2 lists GHG impacts and source categories of fuel pricing policies. Users should check the list to ensure that each of the GHG impacts is categorized appropriately for their policy. Any GHG impacts that are categorized as moderate or major in magnitude

TABLE **6.2**

Example GHG impacts and source categories included/excluded in the GHG assessment boundary

GHG impact	GHG	Likelihood	Relative magnitude	Included or excluded	Explanation
Reduced GHG emissions from reduced VKT in road transport (LDV/HDV)	CO_2	Likely	Major	Included	It is likely that car drivers will react to higher fuel prices, which will lead to reduced vehicle travel. Since CO_2 is the major emissions source in the transport sector, this will have a major impact.
Reduced GHG emissions from reduced VKT in road transport (LDV/HDV)	CH_4	Likely	Minor	Excluded	CO_2 emissions are the most significant GHG source. However, if the policy increases the use of CNG, CH_4 leakage may be significant and should be included.
Reduced GHG emissions from use of less GHG-intensive modes	CO_2	Likely	Major	Included	Depends on policy implementation, and the quality and availability of substitutes, as well as consumer behaviour; considered significant for most fuel pricing policies

TABLE **6.2,** continued

Example GHG impacts and source categories included/excluded in the GHG assessment boundary

GHG impact	GHG	Likelihood	Relative magnitude	Included or excluded	Explanation
Reduced GHG emissions from more efficient VKT	CO_2	Likely	Major	Included	Depends on quality and availability of substitutes, their ability to compete in the market, and consumer behaviour (e.g. mode shift or carpooling); considered significant for most fuel pricing policies
GHG emissions increase, where the revenue is spent on roadways	CO_2	Possible	Major	Excluded for the purposes of the methodology; should be accounted for, where relevant	Depends on how revenues are used; may be significant
GHG emissions reductions increase, where the revenue is spent on public transport infrastructure	CO_2	Possible	Major	Excluded for the purposes of the methodology; should be accounted for, where relevant	Depends on how revenues are used; may be significant

Source: Adapted from WRI (2015).

Abbreviations: CH_4, methane; CNG, compressed natural gas; CO_2, carbon dioxide; HDV, heavy-duty vehicle; LDV, light-duty vehicle; VKT, vehicle kilometres travelled

and very likely, likely or possible in likelihood should be included in the GHG assessment boundary.

6.3 Define the assessment period

The GHG assessment period is the time period over which GHG impacts resulting from the policy are assessed; it is based on the time horizon of the GHG impacts included in the GHG assessment boundary. It is a *key recommendation* to define the assessment period.

Where possible, users should align the GHG assessment period with other assessments being conducted using ICAT methodologies. For example, where users are assessing the pricing policy's sustainable development impacts using the ICAT *Sustainable Development Methodology* in addition to assessing GHG impacts, the assessment period should be the same.

The ex-ante GHG assessment period is usually determined by the longest-term impact included in the GHG assessment boundary. The GHG assessment period can be longer than the implementation period, and should be as long as necessary to capture the full range of significant impacts, based on when they are expected to occur.

For an ex-post assessment, the assessment period can be the period between the date the policy is implemented and the date of the assessment, or it can be a shorter period between these two dates. The assessment period for a combined ex-ante and ex-post assessment should consist of both an ex-ante assessment period and an ex-post assessment period.

Users should consider the assessment objectives and stakeholders' needs when determining the assessment period. Where the objective is to understand the expected contribution of the policy towards achieving a country's NDC, it may be most appropriate to align the assessment period with the NDC implementation period (e.g. ending in 2030). To align with the Paris Agreement modalities, procedures and guidelines, projections should begin from the most recent year of data and extend at least 15 years beyond the next year ending in zero or five. To align with longer-term trends and planning, users should select an end date such as 2040 or 2050. In addition, users can separately estimate and report impacts over any other time periods that are relevant. For example, if the implementation period is 2020–2040, a user can separately estimate and report impacts over the periods 2020–2030, 2030–2040 and 2020–2040.

6.4 Identify sustainable development impacts (if relevant)

Pricing policies have other sustainable development impacts in addition to their GHG impacts. Sustainable development impacts are changes in environmental, social or economic conditions that result from a policy, such as changes in economic activity, employment, public health, air quality and energy security.

Table 6.3 shows examples of sustainable development impacts associated with pricing policies. Refer to the ICAT *Sustainable Development Methodology* for the method for conducting a full assessment of sustainable development impacts of a policy.

TABLE **6.3**

Examples of sustainable development impacts and indicators relevant to transport pricing policies

Impact categories	Indicators
Environmental impacts	
Air quality and health impacts of air pollution (SDGs 3, 11, 12)	• Emissions of air pollutants such as particulate matter ($PM_{2.5}$, PM_{10}), ammonia, ground-level ozone (resulting from VOCs and NO_x), carbon monoxide, sulfur dioxide, nitrogen dioxide, fly ash, dust, lead, mercury, and other toxic pollutants (t/year) • Concentration of air pollutants (mg/m^3) • Concentration of aerosol particles (mg/m^3) • Indoor and outdoor air quality • Morbidity (DALYs, QALYs and ADALYs) • Mortality (avoided premature deaths per year)
Energy (SDG 7)	• Energy consumption • Energy efficiency • Energy generated by source • Renewable energy generation • Renewable energy share of total final energy consumption • Primary energy intensity of the economy (e.g. tonnes of oil equivalent/GDP)
Depletion of non-renewable resources	• Consumption of mineral resources • Consumption of fossil fuels • Scarcity of resources
Social impacts	
Illness and death (SDG 3)	• Life expectancy (years) • Avoided premature deaths per year • Morbidity (DALYs, QALYs and ADALYs) • Prevalence of, or reduction in, respiratory illnesses

TABLE **6.3,** continued

Examples of sustainable development impacts and indicators relevant to transport pricing policies

Impact categories	Indicators
Social impacts, continued	
Mobility (SDG 11)	• Number of people or proportion of population with convenient access to employment, schools, health care or recreation, by sex, age and persons with disabilities
Traffic congestion	• Time lost during transportation • Economic cost of time lost
Road safety (SDGs 3, 11)	• Number of deaths and injuries from road traffic accidents per year
Economic impacts	
Costs and cost savings	• Fuel costs or cost savings • Health-care costs or cost savings • Economic costs of human health losses from air pollution based on social welfare indicator (ADALYs monetized in terms of social welfare valuation based on willingness to pay VSL estimates) or national accounts indicator (ADALYs monetized based on foregone output estimates based on productivity/wage approaches)
Government budget surplus/deficit	• Annual revenue • Annual expenditures • Annual surplus or deficit

Source: Adapted from ICAT *Sustainable Development Methodology*.

Abbreviations: ADALY, averted disability-adjusted life year; DALY, disability-adjusted life year; GDP, gross domestic product; NO_x, nitrogen oxides; QALY, quality-adjusted life year; SDG, Sustainable Development Goal; VOC, volatile organic compound; VSL, value of a statistical life

PART III

Assessing impacts

7 Estimating the baseline scenario and emissions

Estimating the GHG impacts of a transport pricing policy requires a reference case, or baseline scenario, against which impacts are estimated. The baseline scenario represents the events or conditions that would most likely occur in the absence of the policy being assessed. Properly estimating the emissions associated with this scenario – the baseline emissions – is a critical step in estimating the achieved GHG impacts of a pricing policy.

Checklist of key recommendations

- Estimate base year emissions
- Develop a projection of baseline emissions for each year of the assessment period

7.1 Introduction to estimating base year emissions

It is a *key recommendation* to estimate base year emissions. The base year is the year in the assessment from which projections will be made into the future. Where the results of the assessment will be used in the GHG accounting of an NDC, users should consider aligning the base year for this assessment with the base year of the NDC and related targets. For this purpose, input parameters (e.g. activity data, emission factors, socioeconomic data) used to estimate baseline emissions of transport pricing policies should be aligned with similar parameters used for setting NDC targets, and relevant GHG accounting and reporting under the Paris Agreement.

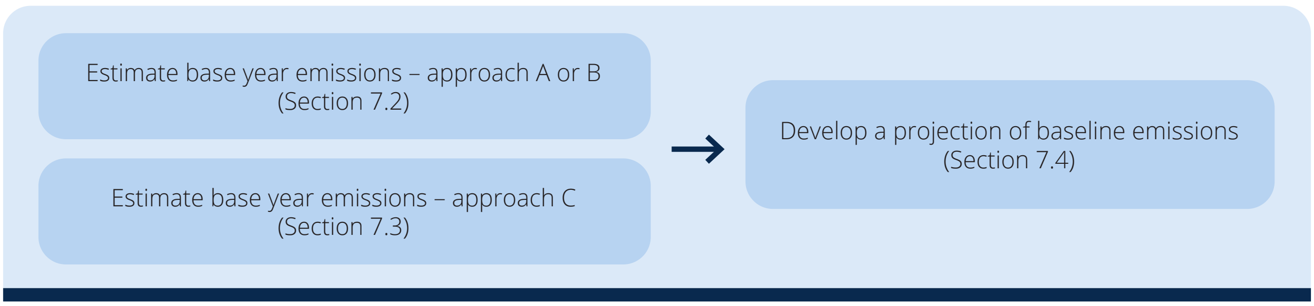
Calculation of base year emissions for an individual year uses activity data on the key drivers of emissions, primarily from fuel consumption, and emission factors for the fuels combusted nationally. Consistent with the definition of the GHG assessment boundary, only carbon dioxide (CO_2) emissions are included; for simplification, emissions of methane (CH_4) and nitrous oxide (N_2O) are excluded.

Refer to Section 4.2.2 for guidance on whether to apply approach A, B or C, or both approaches B and C, to estimate base year emissions. Users should choose the approach that is appropriate based on data and capacity available. Approaches A and B use the same baseline scenario. Section 7.2 provides guidance for approaches A and B. For approach C, Section 7.3 provides guidance on defining the baseline scenario and calculating base year emissions for an individual year.

Approaches A and B use top-down, national-level data to estimate base year emissions for policies implemented at the national level. In contrast, approach C is particularly suitable for the city level where activity data (i.e. fuels used) are available for activities within the city boundary.[20] In both

FIGURE **7.1**

Overview of steps in the chapter



[20] System boundaries can be chosen as “fuel used” or “fuel sold” within the geographical borders; see Executive Body for the Convention on Long-range Transboundary Air Pollution (2015).

cases, the baseline scenario is considered to be a continuation of the conditions that exist in the absence of the new policy.

Base year emissions are calculated for an individual year using activity data and emission factors. Activity data are related to the key driver of emissions from transport, which is primarily fuel consumption. The emission factor is related to the carbon content of the vehicle fuels used and is expressed as tonnes of CO_2 per unit of fuel. In this methodology, only gasoline and diesel are included for approaches A and B. However, the same approach can be applied to other fuels (e.g. LPG) by using analogous equations with different input data (i.e. travel activity data, emission factors and elasticity values).

7.2 Estimate base year emissions: approaches A and B

Figure 7.2 provides an overview of the steps for approaches A and B.

The basic calculation for approaches A and B multiplies activity data with an emission factor to determine base year emissions (see Figure 7.3). The activity data consist of vehicle fuel use for the year selected in the baseline scenario, expressed in units of energy, volume or mass. Available national data for the year should be used. In the simplest case, this amounts to the observed vehicle fuel use for a year in the absence of the policy.

If transport fuel includes a share of biofuels (e.g. bioethanol or biodiesel), the share of these fuels within the fuel mix should be sourced from government or distributor data. As a simplification, the GHG emissions from biofuels can be assumed to be zero. These emissions should be considered in the applied emission factor when calculating the emissions following Figure 7.3. For example, in a country that applies a biogenic share of 5% in transport fuels, the emission factor is reduced by 5%. It is important that, where biofuels are relevant, this simplification is transparently indicated for monitoring and reporting purposes (see Chapters 11 and 12). A more comprehensive way to assess the emissions of biofuels within the ground transport

FIGURE **7.2**

Overview of steps for approaches A and B

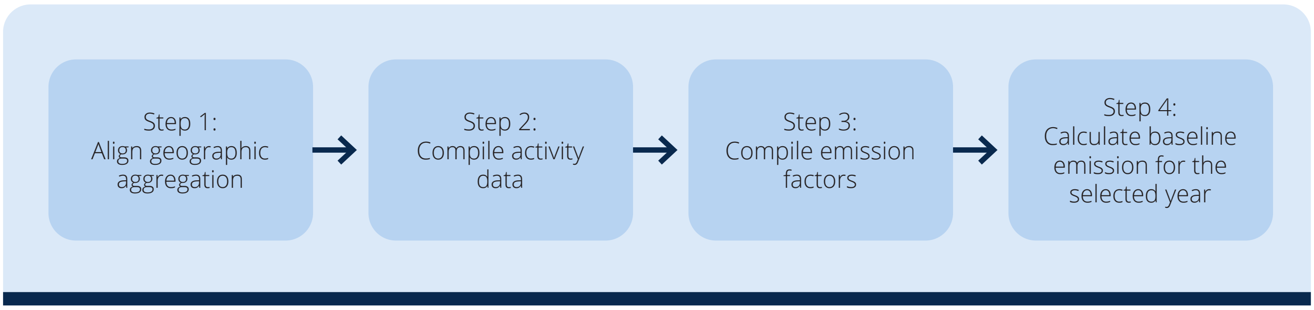
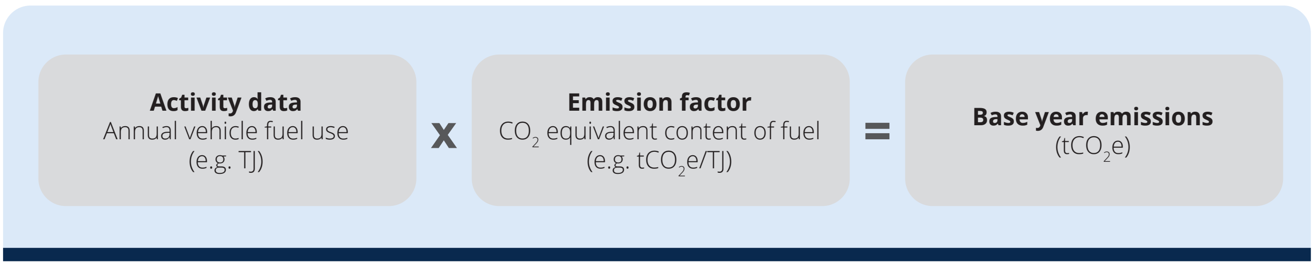


FIGURE **7.3**

Base year CO_2 emissions calculation for approaches A and B



system is shown in approach C (see Sections 7.3 and 8.2.3).

7.2.1 Approach A: Estimate impact of the policy on the national vehicle fleet

Approach A is a simple approach to calculating GHG (CO_2 only) impacts where only aggregated data are available. It is appropriate to use approach A where the activity data on annual fuel consumption are available as an unspecified mix of gasoline, diesel and/or other transport fuels. If it is known or assumed that freight transportation is mainly powered by diesel fuel, approach B should be applied.

The four steps for approach A are described below.

Step 1: Align geographic aggregation
Confirm that the geographic aggregation of the activity data on annual fuel consumption is the same as the geographic level at which the policy will be applied. In most cases, the geographic aggregation is the national border. The simplified approach A ignores upstream emissions from fuels, whether or not these occur within the national borders.[21]

Where activity data on fuel use are available at a smaller geographic aggregation, such as for a region or a province, the same calculation method described here can be used to calculate base year emissions for a regional or provincial policy.

Step 2: Compile activity data
The activity data are the annual fuel quantity combusted by vehicles for ground transport (F_y). In this approach, the user obtains aggregated data for all vehicle fuel types together, in energy units (TJ or similar). Users can obtain the data from (in order of priority) (1) the national energy balance or similar national energy statistics, (2) a data-collection process or (3) international sources.

During the compilation of activity data, select any conversion factors needed to convert the fuel-use data into units that are compatible for multiplication with the emission factor. The default IPCC emission factors are expressed in units of $kgCO_2/TJ$ on a net calorific basis (i.e. NCVs are applied to determine the usable heat energy released through combustion), so fuel activity data should be in energy units. It is important to determine whether the energy units are expressed on a net calorific basis. Where a different basis is used, the values should be converted before applying the emission factor (e.g. using the method provided by the IPCC[22]).

Data on total fuel use are often made available by the ministry of energy or equivalent in the national energy balance, although entities such as the ministry of transport, ministry of finance or similar governmental bodies may manage these data in some cases. National energy balances are also published by the International Renewable Energy Agency (IRENA).[23] Where using data from the national energy balance, ensure that the boundaries of the data set are clear. For example, reported diesel use may also include consumption for sources that are not related to transport (e.g. water pumps, diesel generator sets for power generation).

In the absence of a robust national data source, the alternative is to build the activity data set directly. In this case, consider the sources of transport fuel used in the country. Depending on the sources (e.g. national production and/or imports), data can be derived from refineries, fuel importers or customs authorities. Users could also use well-designed and well-executed surveys of fuel distributors or fuelling stations to build the data set. In the latter case, it is recommended that users refer to accepted guidance on survey design and execution to ensure a robust result. These two approaches for building an activity data set directly may require significant resources.

Where building an activity data set directly is too resource-intensive, users can use international sources, such as International Energy Agency (IEA) and IRENA country statistics.[24]

For all data sources, analyse the compiled fuel-use data while accounting for the following:

- **Data vintage.** Note the year that the activity data represent and not only their year of publication. The delay between data compilation, analysis and publication may be considerable. A study published in 2016 may report data for the year 2013.

[21] This is a conservative assumption since, by ignoring upstream emissions, emissions reductions are also excluded from the results.

[22] IPCC (2006). Note, the enhanced transparency framework states that "Each Party shall use the 2006 IPCC Guidelines and any subsequent version or refinement of the IPCC Guidelines agreed upon by the Conference of the Parties serving as the meeting of the Parties to the Paris Agreement (CMA)".

[23] https://irena.org/Statistics

[24] Available at: www.iea.org/statistics and https://irena.org/Statistics.

- **Boundaries of the data set.** Consider the likelihood of over- or under-reporting of transport fuel use within the statistics. Over-reporting may occur where there are significant non-transport uses of typical transport fuels. Situations that could generate this type of problem are
  - the presence of significant backup electricity generation at private homes using diesel generators
  - for countries with subsidized fuel, black-market export of transport fuels to neighbouring countries and/or significant fuel sales to vehicles that operate in neighbouring countries ("tank tourism").

If a data set used seems to be subject to significant over- or under-reporting, provide an estimate of the magnitude of the impact, justify the assumption, and incorporate it into the calculations. Alternatively, report the related uncertainty but omit the consideration from the calculations.

Table 7.1 provides an overview of the activity data parameter for approach A, and possible data sources.

For approach A, since all fuel types are aggregated in the activity data, estimate the share of different fuel types on an energy basis (i.e. expressed in units of energy – TJ). If there are reliable indicators on the share of gasoline versus diesel and/or other transport fuel use in the country (e.g. different taxation or subsidy, reliable data on shares in passenger and freight transport), apply these values to define the proportion (S_i). Otherwise, a default assumption can be applied.

Where activity data are expressed in volume units (e.g. in litres or gallons), the user will need to apply fuel density values (ρ_i) to convert the data to mass units. Where activity data are expressed in mass units, the NCV (NCV_i) should be applied to obtain energy units. In either case, it is preferable to use national values to make these conversions. In the absence of appropriate national data, reliable international sources or default values can be applied.

Table 7.2 provides an overview of the conversion factor for activity data for approach A, and possible data sources.

Step 3: Compile emission factors

The emission factors (EF_i) represent the amount of CO_2 emissions expected from combusting a unit of fuel, and are based on the total carbon content of the fuel. In approach A, emissions of CH_4 and N_2O are ignored for simplicity. Users should take into account the different transport fuels used in the country and determine an emission factor for each fuel type *i*. Emission factors can be obtained from (in order of priority) (1) national energy or environmental statistics, (2) national fuel providers or (3) default values from international sources.

For approaches A and B, emission factors consider only tank-to-wheel emissions and no "upstream" or well-to-tank emissions (i.e. emissions that stem from electricity production and distribution).

Table 7.3 provides an overview of the emission factor parameters for approach A, and possible data sources.

TABLE **7.1**

Activity parameter for approach A

Parameter	Description	Unit	Sources
F_y	Total fuel used for ground transport in year *y* (unspecified mix of gasoline, diesel and/or other transport fuels)	TJ	In order of preference: • national energy balance or similar national energy statistics • data-collection process • international sources, such as IEA

TABLE **7.2**

Conversion factors for activity data for approach A

Conversion factor	Description	Unit	Sources
S_i	Share of fuel type *i* in ground transport combustion, on an energy basis (i.e. expressed in units of energy – TJ)	%	In order of preference: • national statistics • indicative national reports or studies, or expert estimate • assumption of a share of 50% diesel and 50% motor gasoline, in the absence of any suitable national information

TABLE **7.3**

Emission factor parameters for approach A

Parameter	Description	Unit	Sources
EF_i	Emission factor for fuel type *i*	tCO_2/TJ	In order of preference: • national energy or environmental statistics • national fuel providers, such as refineries or fuel importers, based on their measurements • default values – diesel: 74.1 tCO_2/TJ; gasoline: 69.3 tCO_2/TJ[a]

[a] Both values are from both IPCC (2006), vol. 2, Chapter 3, Table 3.2.1.

Step 4: Calculate base year emissions for the selected year
Calculate base year emissions for the selected year *y* by using the collected activity data (fuel used, F_y; share of fuel type, S_i) and emission factors (EF_i) as inputs to equation 7.1. For each fuel type *i*, the share and emission factor are multiplied by the total fuel amount. Then the results of the multiplication for each fuel type are summed to obtain the total base year emissions for the year under consideration (BE_y).

Equation 7.1: Estimation of base year emissions from fuel use for approach A

$$BE_y = \sum_i F_y\,(\text{in TJ}) \times S_i\,(\text{in }\%) \times EF_i\,(\text{in tCO}_2/\text{TJ})$$

The results represent the GHG emissions (CO_2 only) from fuel consumption in ground transport for the selected year in the baseline scenario (i.e. in the absence of the policy), in units of tCO_2.

Box 7.1 provides an example calculation of base year emissions using approach A.

7.2.2 Approach B: Estimate impact of the policy on gasoline and diesel vehicles of the national vehicle fleet

Approach B is a simple approach to calculating GHG impacts (CO_2 only) where separate data are available on the annual fuel consumption for gasoline and diesel. It is appropriate to use approach B where separate data are available on annual fuel consumption for gasoline and diesel, but not on PKM or TKM for freight.

Approach B allows users to separately assess the impacts of the policy on vehicles using gasoline and on those using diesel as proxies for light-duty vehicles (LDVs), which tend to use gasoline, and heavy-duty vehicles (HDVs), which tend to use diesel.

BOX **7.1**

Example of calculation of base year emissions

A government plans to implement a national fuel levy on gasoline and diesel that will target LDVs in the form of a fixed sum per litre – higher for gasoline than for diesel. The national energy balance breaks down total fuel use by sector. The transport sector is a major source of demand, with an annual energy use of 782,000 TJ. The Ministry of Transport knows that this quantity comes from liquid fuels, but there is no breakdown by specific fuel type. Still, the ministry wishes to calculate the emissions reductions from implementing the fuel levy, and they start by calculating the base year emissions for one year.

The ministry staff follow step 1 (Align geographic aggregation) and determine that the data (national) align perfectly with the new levy that will be applied nationwide.

Next, they undertake step 2 (Compile activity data), and find that the data from the most recent national energy balance for the transport sector of 782,000 TJ is the value to apply. Also, since the ministry does not have a clear idea of the split in liquid fuel use in the sector, they choose to apply a share of 50% for gasoline and 50% for diesel.

Under step 3 (Compile emission factors), the ministry staff choose to use the default values, since other values are not available.

The ministry staff determine the base year emissions by applying step 4 (Calculate base year emissions for the selected year):

Base year emissions for year y = (782,000 TJ × 50% × 74.1 tCO_2/TJ) + (782,000 TJ × 50% × 69.3 tCO_2/TJ)
= 28,973,100 tCO_2 + 27,096,300 tCO_2 = 56,069,400 tCO_2

Thus, the result shows that emissions in the base year are about 56 $MtCO_2$.

LDVs have a gross vehicle mass (GVM) up to around 3,900 kg,[25] such as typical passenger cars (with a GVM of around 1,800 kg). They are used mainly for personal travel. HDVs have a higher GVM and are used for transport of freight and road-based public transport.

This disaggregation adds precision to the calculation of base year emissions and overall GHG impacts, since policies such as taxes are frequently applied differently to vehicles for personal travel (LDV) and commercial vehicles (HDV). Price elasticities are often different for these two groups of vehicles,[26] accounting for the fact that there is not a perfect congruency between fuel type and vehicle category.

Approach B follows the same steps as approach A, set out below.

Step 1: Align geographic aggregation

Use the same approach as in step 1 of approach A (Section 7.1) to align the geographic aggregation of the activity data and the policy. The simplified approach B also ignores upstream emissions from fuels, whether or not these occur within national borders.[27]

Step 2: Compile activity data

The activity data are the annual amount of gasoline fuel combusted by vehicles for ground transport ($F_{G,y}$) and the annual amount of diesel fuel combusted by vehicles for ground transport ($F_{D,y}$). Where other types of fuel are frequently used for ground transport, such as LPG, this approach can be applied to cover the other fuels as well, provided that disaggregated data are available. Users can obtain disaggregated annual fuel data from (in order of priority) (1) the national energy balance, or similar national energy or transport statistics, (2) a data-collection process or (3) international sources.

In the absence of a robust national source, the alternative is to build the data set directly. In this case, refer to the guidance in step 2 of approach A (Section 7.1).

[25] U.S. EPA (2017). The definition of the LDV category limits varies somewhat from country to country per regulations.

[26] Dahl (2012).

[27] Users should note that this is a conservative assumption since, by ignoring upstream emissions, emissions reductions are also excluded from the results.

The third alternative is to use international sources, such as IEA and IRENA country statistics.[28]

For all data sources, analyse the compiled fuel-use data while accounting for the following:

- **Data vintage.** Note the year that the activity data represent and not only their year of publication. The delay between data compilation, analysis and publication may be considerable. A study published in 2016 may report data for the year 2013.
- **Boundaries of the data set.** Consider the likelihood of over- or under-reporting of transport fuel use within the statistics. Over-reporting may occur where there are significant non-transport uses of typical transport fuels. Situations that could generate this type of problem are
  - the presence of significant backup electricity generation at private homes using diesel generators
  - for countries with subsidized fuel, black-market export of transport fuels to neighbouring countries and/or significant fuel sales to vehicles that operate in neighbouring countries ("tank tourism").

If evidence exists suggesting that there is significant over- or under-reporting, provide an estimate of the magnitude of the impact, justify the assumption, and incorporate it into the calculations. Alternatively, report the related uncertainty but omit the consideration from the calculations.

During the compilation of activity data, select any conversion factors needed to convert the fuel-use data into units that are compatible for multiplication with the emission factor. The default IPCC emission factors are expressed in units of $kgCO_2/TJ$ on a net calorific basis (i.e. NCVs are applied to determine the usable heat energy released through the combustion), so fuel activity data should be in energy units. It is important to determine whether the energy units are expressed on a net calorific basis. Where a different basis is used, the values should be converted before applying the emission factor (e.g. using the method provided by the IPCC[29]).

Table 7.4 provides an overview of activity parameters for approach B, and possible data sources.

Where activity data are expressed in volume units (e.g. in litres or gallons), the user will need to apply fuel density values (ρ_i) to convert the data to mass units. Where activity data are expressed in mass units, the NCV (NCV_i) should be applied to obtain energy units. In either case, it is preferable to use national values to make these conversions. In the absence of appropriate national data, reliable international sources or default values can be applied.

Table 7.5 provides an overview of conversion factors for activity data for approach B, and possible sources of data.

TABLE **7.4**

Activity parameters for approach B

Parameter	Description	Unit	Sources
$F_{G,y}$	Total gasoline fuel used for ground transport in year *y*	TJ	In order of preference: • national energy balance or similar national energy statistics • data-collection process • international sources, such as IEA and IRENA
$F_{D,y}$	Total diesel fuel used for ground transport in year *y*	TJ	

[28] Available at: www.iea.org/statistics and and https://irena.org/Statistics.

[29] IPCC (2006).

TABLE **7.5**

Conversion factors for activity data for approach B

Conversion factor	Description	Unit	Sources
ρ_i	Density of fuel type *i*	kg/m^3	In order of priority: • national energy statistics • reliable international sources[a] • default values – diesel: 835 kg/m^3 at 15°C;[b] gasoline: 720 kg/m^3 at 15°C[c]
NCV_i	NCV of fuel type *i*	TJ/Gg	In order of priority: • national energy statistics • reliable international sources • default values – diesel: 43.0 TJ/Gg; gasoline: 44.3 TJ/Gg[d]

[a] For more information on data collection, see the IPCC Guidelines (www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_2_Ch2_DataCollection.pdf).

[b] Directive 1998/69/EC (www.dieselnet.com/standards/eu/fuel_reference.php)

[c] NOAA (no date).

[d] Both values are from IPCC (2006), vol. 2. Chapter 1, Table 1.2.

Where activity data are compiled in volume or mass units (fuel consumption in litres or in Gg, labelled $FC_{i,y}$), use the following equations to calculate energy units (labelled $F_{i,y}$).

Equation 7.2: Estimation of gasoline and diesel use in energy units (TJ) for approach B (input: volume units in L)

$$F_{i,y} \text{ in energy units (TJ)} =$$
$$FC_{i,y} \text{ in volume units (L)} \times \rho_i \times NCV_i \div 10^9$$

Equation 7.3: Estimation of gasoline and diesel use in energy units (TJ) for approach B (input: mass units in Gg)

$$F_{i,y} \text{ in energy units (TJ)} =$$
$$FC_{i,y} \text{ in mass units (Gg)} \times NCV_i$$

Step 3: Compile emission factors

The emission factors (EF_i) represent the quantity of CO_2 emissions expected from combusting a unit of fuel, and are based on the total carbon content of the fuel. Approach B also ignores emissions of CH_4 and N_2O for simplicity. Determine an emission factor for both gasoline and diesel fuel. Emission factors can be obtained from (in order of priority) (1) national energy or environmental statistics, (2) national fuel providers or (3) default values from international sources.

For approaches A and B, emission factors consider only tank-to-wheel emissions and no “upstream” or well-to-tank emissions.

Table 7.6 provides emission factor parameters for approach B.

Step 4: Calculate base year emissions for the selected year

Calculate base year emissions for the selected year *y* by using the activity data and emission factors for the different fuels as inputs to the following equations. For each fuel type *i*, the emission factor is multiplied by the total fuel amount to obtain the total base year emissions ($BE_{i,y}$) associated with that fuel type for the year *y* under consideration.

Equation 7.4: Estimation of base year emissions from gasoline and diesel use for approach B

Base year emissions from gasoline for year *y*:

$$BE_{gasoline,y} = F_{G,y} \text{ (in TJ)} \times EF_G \text{ (in tCO}_2\text{/TJ)}$$

Base year emissions from diesel for year *y*:

$$BE_{diesel,y} = F_{D,y} \text{ (in TJ)} \times EF_D \text{ (in tCO}_2\text{/TJ)}$$

The results represent the CO_2 emissions from gasoline and diesel consumption in ground transport for the selected year in the baseline scenario, in the absence of the policy.

Users wishing to consider aggregated base year emissions for the whole national vehicle fleet may sum the emissions from the two fuels.

Box 7.2 provides an example calculation of base year emissions using approach B.

TABLE **7.6**

Emission factor parameters for approach B

Parameter	Description	Unit	Sources
EF_G	Emission factor for gasoline fuel	tCO_2/TJ	In order of priority: • national energy or environmental statistics • national fuel providers, such as refineries or fuel importers, based on their measurements • default values – gasoline: 69.3 tCO_2/TJ; diesel: 74.1 tCO_2/TJ[a]
EF_D	Emission factor for diesel fuel	tCO_2/TJ	

[a] Both values are from both IPCC (2006), vol. 2, Chapter 3, Table 3.2.1.

BOX **7.2**

Example of calculation of base year emissions for approach B

A government plans to implement a national fuel levy on gasoline and diesel that will target LDVs in the form of a fixed sum per litre – higher for gasoline than for diesel. The national energy balance breaks down total fuel use by sector. The transport sector is a major source of demand, with an annual energy use of 782,000 TJ. The Ministry of Transport has further data showing that 7,860 Gg of gasoline ($FC_{G,y}$) and 8,000 Gg of diesel ($FC_{D,y}$) were used that year. The ministry wishes to calculate the emissions reductions from implementing the fuel levy, which they expect will reduce the emissions from LDVs using gasoline more than from other vehicles. They start by calculating the disaggregated base year emissions for one year.

The ministry staff follow step 1 (Align geographic aggregation) and determine that the data (national) align perfectly with the new levy that will be applied nationwide.

Next, they undertake step 2 (Compile activity data), and find that the data from the most recent national energy balance for the transport sector of 782,000 TJ is consistent with the fuel consumption data in Gg from the ministry. They decide to use the default NCVs to convert the fuel amounts to energy units.

$F_{G,y}$ = 7,860 Gg × 44.3 TJ/Gg = 348,198 TJ (equation 7.3)

$F_{D,y}$ = 8,000 Gg × 43.0 TJ/Gg = 344,000 TJ (equation 7.3)

Under step 3 (Compile emission factors), the ministry staff choose to use the default values, since other values are not available.

The ministry staff determine the base year emissions by applying step 4 (Calculate base year emissions for the selected year):

Base year emissions from gasoline for year *y* $BE_{gasoline,y}$ = 348,198 TJ × 69.3 tCO_2/TJ = 24,130,121 tCO_2 (see equation 7.4)

Base year emissions from diesel for year *y* $BE_{diesel,y}$ = 344,000 TJ × 74.1 tCO_2/TJ = 25,490,400 tCO_2 (see equation 7.4)

Thus, the result shows that emissions in the base year from the two fuels are about 50 $MtCO_2$ (49,620,521 tCO_2).

7.3 Estimate base year emissions: approach C

Approach C focuses on ground transport and considers the substitution of individual motorized transport by cars with public transport (and non-motorized transport). In the context of this section, private road passenger transport (i.e. on-road gasoline passenger cars only) and public transport (i.e. diesel buses and diesel or electric rail systems) are considered. This approach enables assessment of a policy's impact on both GHG emissions and on transport mode shifts by using cross-elasticities (see Section 8.1.1 for an explanation of cross-elasticities). For this purpose, data on distances travelled for the analysed transport modes (e.g. private road vehicles, bus systems, rail systems) are also collected.

This methodology only considers the use of gasoline, diesel and electricity. However, the calculation method can be applied to other fuels (e.g. LPG) by using analogous equations with different input data (i.e. travel activity data, emission factors and elasticity values).

Also, the analysis of mode shifts in the methodology is restricted to public passenger transport. The methodology can also be applied to shifts to electric mobility, CNG or non-motorized transport (if data are available), based on the equations shown for mode shifts to public transport.

In contrast to approaches A and B, which use top-down data on energy use, approach C uses both top-down energy-use data and bottom-up travel activity data to estimate base year emissions (see Section 3.2.1 for more explanation of top-down and bottom-up data). Approach C therefore is not directly comparable to approaches A and B.

There are two main differences:

- Freight transport cannot be assessed with the proposed calculation (although users can apply the approach to freight transport as well as using different input data and cross-price elasticities).
- It is necessary to adjust the system boundaries to urban regions instead of to the national level (because the proposed cross-price elasticities might not work for rural areas, and because of data availability).

As a result, approach C will only allow users to quantify a portion of the emissions reductions achieved through the policy. However, the approach provides further information regarding mode shift than approaches A and B.

The method is based on the ASIF terminology (see Appendix E in this document and Section 2 in the *Reference Document on Measurement, Reporting and Verification in the Transport Sector*). It is appropriate to use approach C where bottom-up travel activity data for passenger transport, such as PKM for different modes of passenger transport, are available separately for gasoline, diesel and electricity, with an appropriate emission factor. See Figure 7.4 for the formula for calculating base year emissions using approach C. In addition to calculating total base year emissions, the base year emissions are also divided by PKM (see Figure 7.5) to obtain a ratio that can be used to quantify the impacts of the policy in Section 8.2.

FIGURE **7.4**

Calculation of total base year GHG emissions for approach C

Activity data
Gasoline fuel use
Diesel fuel use
Electricity use
(e.g. TJ)

x

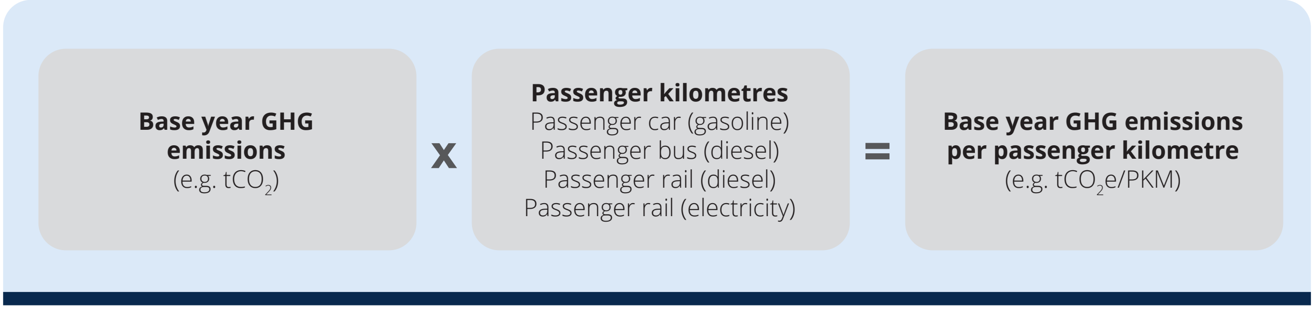
Emission factor
CO_2 content of fuel/electricity
(e.g. tCO_2e/TJ)

=

Base year emissions
(e.g. tCO_2e)

FIGURE **7.5**

Calculation of base year GHG emissions per PKM



If transport fuel contains a certain share of biofuels (e.g. bioethanol or biodiesel), the share of these fuels within the fuel mix should be sourced from government or distributor data. This share may change over time. The emissions of the biofuel share and the fossil fuel share can then be calculated separately (using separate activity data and emission factors) and summed to reflect the emissions from the fuel consumed (consisting of both biofuel and fossil fuel fractions). The emissions from the biofuel can be calculated using analogous equations to the fossil fuel share. If possible, country-specific emission factors (and, where relevant, NCVs) should be used. If such country-specific data are not available, the Renewable Energy Directive[30] provides default values that can be used.

To calculate base year emissions for passenger transport, follow the steps in Figure 7.6.

7.3.1 Step 1: Align geographic aggregation

Follow the same procedure as for step 1 of approaches A and B (Section 7.2.1) to align the geographic aggregation of the activity data and the policy.

7.3.2 Step 2: Estimate activity data for road and rail passenger transport (in energy units)

Table 7.7 lists the activity data needed in mass units to calculate base year emissions.

[30] European Commission (2009). The directive is currently being revised.

FIGURE **7.6**

Overview of steps for approach C

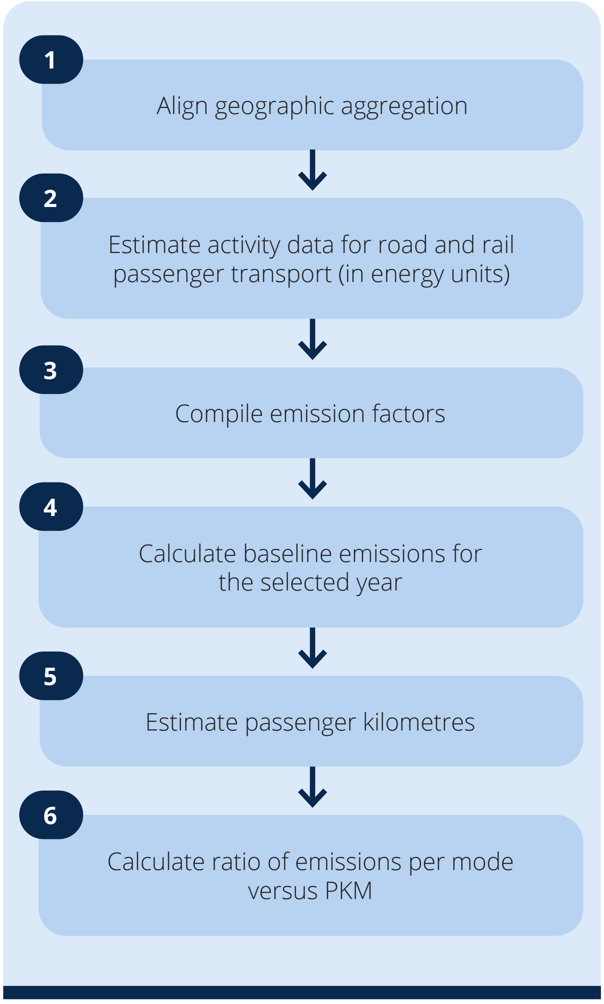


TABLE **7.7**

Activity data for approach C (in energy units)

Parameter	Activity data (in energy units)	Unit
$F_{i,j,y}$	Total fuel energy *i* (from gasoline, diesel and electricity) used per mode *j* of passenger transport (road and rail) in year *y* Example: $F_{diesel,rail,2020}$ = total energy used (in TJ) from diesel fuels in rail passenger transport in the year 2020	TJ
$PKM_{i,j,y}$	Total PKM travelled per mode *j* of passenger transport (road and rail) in year *y* Example: $PKM_{diesel,rail,2020}$ = total PKM travelled in rail passenger transport with diesel fuel in the year 2020	TJ

The default IPCC emission factors for fuel combustion are expressed in units of $kgCO_2$/TJ on a net calorific basis (i.e. NCVs are applied to determine the usable heat energy released through combustion), so fuel activity data should be in energy units. It is important to determine whether the energy units are expressed on a net calorific basis. If a different basis is used, the values should be converted before applying the emission factor – for example, using the method provided by the IPCC.[31]

Estimation of the bottom-up travel activity data and calculation of the fuel energy used ($F_{x,i,y}$) differ for road and rail transport. The two modes are therefore differentiated in steps 2a and 2b.

Step 2a: Estimate bottom-up travel activity data and fuel energy use for road passenger transport

To estimate the activity data for road passenger transport in mass units (TJ), as shown in Table 7.7, follow these three steps:

1. Estimate **activity data in volume units** (total litres of fuel used; $FC_{i,j,y}$) for each fuel type *i* and each passenger transport mode *j* in the respective year *y* according to bottom-up travel activity parameters (e.g. distance travelled, average fuel consumption).

2. Estimate **PKM** ($PKM_{i,j,y}$) for each passenger transport mode *j* in the respective year *y* according to bottom-up travel activity parameters (e.g. distance travelled, load factor).

3. Multiply the total litres of fuel used ($FC_{i,j,y}$) by **conversion factors** (e.g. NCV, density) to estimate the total fuel energy used (TJ; $F_{i,j,y}$) for each fuel type *i* and each passenger transport mode *j* in the respective year *y*.

Two outputs are obtained from these three steps. First, the total fuel energy used is obtained in energy units. This is the relevant activity data for calculating the base year emissions. Second, users estimate PKM data to estimate mode shifts and demand changes due to the impacts of the policy (based on cross-elasticities; for more information, see Section 8.1.4).

Table 7.8 gives an overview of relevant bottom-up travel activity parameters, including possible data sources for passenger cars and buses. Where possible, use data from municipal, regional or national statistics, studies or surveys. Where these data are not available, international default values or comparable data from other cities or countries can be used.[32]

[31] Available at: www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf#page=17.

[32] For further information about parameter estimation, refer to UNFCCC (2014).

TABLE **7.8**

Overview of bottom-up travel activity parameters

Parameter	Description	Unit	Sources[a]
$d_{i,j,y}$ Distance travelled	Vehicle kilometres travelled (with fuel type *i*, mode *j*, in year *y*)	VKT	$d_{gasoline,car,y}$: gasoline-powered passenger cars • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (traffic counting, odometer reading, appropriate vehicle stock data) $d_{diesel,bus,y}$: diesel-powered passenger buses • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national surveys (traffic counting, odometer reading, appropriate vehicle stock data)
$l_{j,y}$ Load factor/ occupancy	Average (per VKT) number of persons travelling in same vehicle (with mode *j* in year *y*) (only needed for estimation of PKM)	Persons per vehicle	$l_{car,y}$: passenger cars • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys • Supra-regional default value (e.g. for continent); otherwise, global default value of 2 persons, including the driver[b] $l_{bus,y}$: passenger buses • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national surveys • Supra-regional default value (e.g. for continent); otherwise, global default value of 40% of total capacity[b,c]
$sfc_{i,j,y}$ Average fuel consumption	Specific fuel consumption Average consumption per VKT in municipal, regional or national fleet (with fuel type *i*, mode *j*, in year *y*)	Litres per VKT	$sfc_{gasoline,car,y}$: gasoline-powered passenger cars • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from manufacturers) • Supra-regional default values (e.g. for continent); otherwise, global default value for gasoline consumption of gasoline cars of 10 L per 100 km (assumption by the authors of this methodology, based on HBEFA[d]) $sfc_{diesel,bus,y}$: diesel-powered passenger buses • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from manufacturers) • Supra-regional default values (e.g. for continent); otherwise, global default value for diesel consumption of diesel buses of 50 L per 100 km (assumption by the authors of this methodology, based on HBEFA[d])

Abbreviation: VKT, vehicle kilometres travelled

[a] Sources are in order of priority.

[b] UNFCCC (2014).

[c] To estimate total capacity of bus transport, estimate fleet composition (i.e. categories of buses with specific capacity), multiply number of buses (category) with specific capacity (category), and sum the results of these calculations for all the categories within the fleet.

[d] HBEFA (2014).

Equation 7.5 shows the calculation of fuel consumption (in volume units) and PKM according to the bottom-up travel activity parameters listed in Table 7.8.

Equation 7.5: Estimation of litres of gasoline and diesel use in car and bus passenger transport for approach C

$$\text{Total fuel consumption } FC_{i,j,y} \text{ in volume units (L)} = d_{i,j,y} \text{ (in VKT)} \times sfc_{i,j,y} \text{ (in L per VKT)}$$

Since the fuel consumption is expressed in volume units (i.e. litres or gallons), as shown in Table 7.8, apply fuel density values (ρ_i) to convert the data to mass units. Where activity data are expressed in mass units, apply the NCV (NCV_i) to obtain energy units. In either case, it is recommended that national values are used to make these conversions. In the absence of appropriate national data, reliable international sources or default values can be applied.

Table 7.9 gives an overview of conversion factors for the estimation of total fuel energy used ($F_{x,i,y}$) for passenger cars and buses using approach C, including units and possible data sources.

With the fuel use in volume units and the conversion parameters, the total fuel use in energy units can be calculated as shown in equation 7.6.

Equation 7.6: Estimation of fuel energy use (in TJ) in car and bus passenger transport for approach C

$$F_{i,j,y} \text{ in energy units (TJ)} = FC_{i,j,y} \text{ in volume units (L)} \times \rho_i \times NCV_i \div 10^9$$

Step 2b: Estimate bottom-up travel activity data and fuel energy use for rail passenger transport

The rail category can include cable car, street car, tramway, metro, commuter rail, light rail and heavy rail. To estimate the activity data for rail passenger transport in mass units (TJ), as shown in Table 7.7, follow these three steps:

1. Estimate **activity data in volume units** (litres of diesel fuel and MWh of electricity; $FC_{i,rail,y}$) for each fuel type *i* used in rail passenger transport in the respective year *y* in a top-down approach (without any bottom-up travel activity parameters).

2. Estimate **PKM** ($PKM_{rail,y}$) for total rail passenger transport (both diesel and electric) in the respective year *y* in a top-down approach

TABLE **7.9**

Conversion factors for estimation of total fuel energy used ($F_{x,i,y}$) for passenger cars and buses for approach C

Conversion factor	Description	Unit	Sources
ρ_i	Density of fuel type *i*	kg/m³	In order of priority: • national energy statistics • reliable international sources • default values – diesel: 835 kg/m³ at 15°C;[a] gasoline: 720 kg/m³ at 15°C[b]
NCV_i	NCV of fuel type *i*	TJ/Gg	In order of priority: • national energy statistics • reliable international sources • default values – diesel: 43.0 TJ/Gg; gasoline: 44.3 TJ/Gg[c]

[a] Directive 1998/69/EC (www.dieselnet.com/standards/eu/fuel_reference.php)

[b] NOAA (no date).

[c] Both values are from IPCC (2006), vol. 2. Chapter 1, Table 1.2.

(without any bottom-up travel activity parameters).

3. Multiply the activity data in volume units ($FC_{i,rail,y}$) by **conversion factors** (e.g. NCV, density, energy conversion units) to estimate the total fuel energy used (TJ; $F_{i,rail,y}$) for each fuel type *i* used in passenger transport in the respective year *y*.

Two outputs are obtained from these three steps. First, the total fuel energy used is provided in energy units separately for diesel-powered and electricity-powered rail, which are necessary for calculating the base year emissions. Second, users estimate PKM data to estimate mode shifts and demand changes due to the impacts of the policy (based on cross-elasticities; for more information, see Section 8.1.4).

Table 7.10 provides an overview of the relevant activity data parameters, including possible data sources, for diesel and electric passenger rail transport.

As in step 2a, fuel consumption of diesel is expressed in volume units (i.e. litres or gallons). The conversion factors from Table 7.9 should be applied again (see equation 7.7 for diesel).

Equation 7.7: Estimation of TJ diesel use in rail passenger transport for approach C

$$F_{diesel,rail,y} \text{ in energy units (TJ)} = FC_{diesel,rail,y} \text{ in volume units (L)} \times \rho_i \times NCV_i \div 10^9$$

Where energy units of electricity use for passenger rail transport have been estimated in MWh, as described in Table 7.10, a conversion to TJ should be conducted, as shown in equation 7.8.

Equation 7.8: Estimation of electricity use (in TJ) in rail passenger transport for approach C

$$F_{electricity,rail,y} \text{ in energy units (TJ)} = FC_{electricity,rail,y} \text{ in MWh} \times 0.0036$$

Collection of more detailed activity data can improve the accuracy and reduce the uncertainty of these

TABLE **7.10**

Overview of activity data parameters

Parameter	Description	Unit	Sources[a]
$FC_{i,rail,y}$ Total fuel consumption	Total fuel and electricity use for rail passenger transport (with fuel type *i* in respective year *y*)	Litres of diesel; MWh of electricity	$FC_{diesel,rail,y}$: diesel-powered passenger rail • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from transit companies) $FC_{electricity,rail,y}$: electricity-powered passenger rail • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national surveys (e.g. from transit companies)
$PKM_{rail,y}$ Distance travelled	Ideally, PKM are available separately for diesel and electricity travel. Otherwise, estimate total PKM travelled in rail passenger transport (in respective year *y*).	PKM	$PKM_{rail,y}$: PKM rail • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from transit companies)

[a] Sources are in order of priority.

results. See the *Reference Document on Measurement, Reporting and Verification in the Transport Sector* for more information on how to improve activity data collection.

7.3.3 Step 3: Compile emission factors

The emission factors (EF_i) represent the amount of CO_2 emissions expected to result from (1) combusting a unit of fuel (e.g. gasoline, diesel), based on the total carbon content of the fuel, and (2) using a unit of electricity, based on the carbon intensity of the national electricity mix. Determine an emission factor separately for gasoline and diesel combustion as well as electricity use. Parameter *EF* is the powering type (i.e. gasoline, diesel or electricity). Approach C ignores emissions of CH_4 and N_2O for simplicity.

For approach C, emission factors for gasoline and diesel consider only tank-to-wheel emissions and no "upstream" or well-to-tank emissions. This is different for electricity, where the emission factor corresponds to the emissions for electricity production. The reason for this is that the emissions from the use phase for electricity are practically zero, and the "well-to-tank" emissions (emissions that stem from electricity production and distribution) are the main contributor to life cycle emissions. In contrast, well-to-tank emissions from combustion of gasoline or diesel are less relevant (10–20%). Table 7.11 provides an overview of emission factor parameters for approach C, including possible data sources for gasoline and diesel fuel emission factors.

7.3.4 Step 4: Calculate base year emissions for the selected year

Calculate base year emissions for the selected year *y* by using the activity data and emission factors for the different fuels as inputs to the following equations. For each fuel type, the emission factor is multiplied by the total fuel amount to obtain the total base year emissions associated with that fuel type for the year in question, as shown in equation 7.9.

Equation 7.9: Estimation of base year emissions for approach C per fuel type and transport mode

$$BE_{i,j,y} \text{ in } CO_2 \text{ emissions } (tCO_2) = FC_{i,j,y} \text{ in energy units (TJ)} \times EF_i \text{ } (tCO_2 \text{ per TJ})$$

TABLE 7.11

Emission factor parameters for approach C

Parameter	Description	Unit	Sources
$EF_{gasoline}$	Emission factor for gasoline fuel	tCO_2/TJ	In order of priority: • national energy or environmental statistics • national fuel providers (e.g. refineries or fuel importers, based on their measurements) • global default values – gasoline: 69,300 $kgCO_2/TJ$; diesel: 74,100 $kgCO_2/TJ$[a]
EF_{diesel}	Emission factor for diesel fuel	tCO_2/TJ	
$EF_{electricity}$	Emission factor for electricity	tCO_2/TJ	In order of priority: • national energy or environmental statistics (electricity mix) • national fuel providers (e.g. refineries or fuel importers, based on their measurements) • supra-regional default value (e.g. for continent); otherwise, global default value – mainly conventional/fossil fuel electricity production: 110,000 $kgCO_2/TJ$; at least 50% renewable share: 220,000 $kgCO_2/TJ$[b]

[a] Both values are from both IPCC (2006), vol. 2, Chapter 3, Table 3.2.1.

[b] Assumption by the authors of this methodology, based on UNFCCC (2014).

7.3.5 Step 5: Estimate PKM

For **road transport** (gasoline cars and diesel buses[33]), the estimation can be conducted as shown in equation 7.10 (for parameters, see step 2a).

For **rail transport**, PKM are ideally estimated separately for the two fuel energy types (diesel and electricity) (see Table 7.10). If this is the case, skip the calculations in equation 7.11 and continue with step 6.

If PKM data are not available for diesel and electricity separately, they can be estimated from total rail PKM (for both diesel- and electricity-powered rail). In this case, the energy efficiencies (η) of diesel and electricity need to be considered, since the operation of a train with electricity is much more efficient than with diesel.[34] They can be differentiated for the two fuel types using equation 7.11.

Equation 7.10: Estimation of PKM for car and bus passenger transport for approach C

$$PKM_{i,car,y} = \sum_i d_{i,car,y} \text{ (in VKT)} \times l_{car,y} \text{ (in persons per vehicle)}$$

$$PKM_{i,bus,y} = \sum_i d_{i,bus,y} \text{ (in VKT)} \times l_{bus,y} \text{ (in persons per vehicle)}$$

Equation 7.11: Estimation of PKM for diesel and electric rail transport for approach C

$$PKM_{diesel,rail,y} = PKM_{rail,y} \times \frac{F_{diesel,rail,y} \times \eta_{diesel}}{((F_{diesel,rail,y} \times \eta_{diesel}) + (F_{electricity,rail,y} \times \eta_{electricity}))}$$

$$PKM_{electricity,rail,y} = PKM_{rail,y} \times \frac{F_{electricity,rail,y} \times \eta_{electricity}}{((F_{diesel,rail,y} \times \eta_{diesel}) + (F_{electricity,rail,y} \times \eta_{electricity}))}$$

7.3.6 Step 6: Calculate ratio of total emissions per mode to PKM

The total base year emissions can now be divided by the PKM, using equation 7.12.

Equation 7.12: Estimation of total base year emissions per PKM for approach C

$$BEPKM_{i,j,y} \text{ in } CO_2 \text{ emissions } (kgCO_2) \text{ per passenger kilometre} = BE_{i,j,y} \, (kgCO_2) \div PKM_{i,j,y}$$

The results are the CO_2 emissions from gasoline, diesel and electricity consumption in road and rail passenger transport, for the selected year in the baseline scenario, in the absence of the policy. Furthermore, users obtain a ratio of this result per PKM.

Users who want to aggregate base year emissions estimated for approach C should sum the total emissions for each mode and for each fuel. Box 7.3 provides an example calculation of base year emissions using approach C.

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[33] As a simplification, the methodology is restricted to gasoline cars and diesel buses for approach C (assuming that most passenger LDV transport is powered with gasoline, whereas most passenger HDV transport is powered with diesel). However, if this assumption does not apply, the calculation method can be applied to other fuels (e.g. diesel passenger cars, LPG) by using analogous equations with different input data (i.e. travel activity data, emission factors and elasticity values).

[34] The assumption is that the energy efficiency of a diesel engine is about 30%, whereas the energy efficiency of an electric engine is about 90% (estimation by authors of this methodology, based on expert judgment).

BOX **7.3**

Example of calculation of base year emissions (values rounded) for approach C

A government plans to implement a national fuel levy on gasoline and diesel that will target LDVs in the form of a fixed sum per litre. The ministry has two main goals. First, it wishes to calculate the emissions reductions in the passenger transport sector resulting from the fuel levy. Second, it plans to assess changes in travel demand for the passenger transport modes that are directly and indirectly affected by the fuel levy.

The ministry staff follow step 1 (Align geographic aggregation) and determines that the data do not align with the new levy that will be applied nationwide. They decide to focus the GHG impact assessment on the capital city. The system boundaries they choose for fuel consumption are restricted to fuels used within the city borders.

Next, they follow step 2 (Compile activity data).

First, the ministry staff estimate the total fuel energy used for **road passenger transport** (cars and buses; step 2a). They obtain the data on vehicle kilometres travelled (VKT) from the national transit authorities (from a traffic counting study):

$d_{gasoline,car,y}$ = 10,900 million VKT

$d_{diesel,bus,y}$ = 980 million VKT

Since no country-specific values are available for the load factors and the average fuel consumption of vehicles, and the ministry has no capacity to conduct a study, they apply the global default factors:

$l_{car,y}$ = 2 persons, including the driver

$l_{bus,y}$ = 40% of total capacity. The ministry staff assume that the buses have 40 seats on average. The average load factor equals 40% × 40 seats = 16 taken seats per VKT.

$sfc_{gasoline,car,y}$ = 10 L per 100 VKT

$sfc_{diesel,bus,y}$ = 50 L per 100 VKT

With these data, the fuel consumption in volume units can be calculated:

$FC_{gasoline,car,y}$ = 10,900,000,000 VKT × 0.1 L per VKT = 1,090 ×106 L of gasoline (equation 7.5)

$FC_{diesel,bus,y}$ = 980,000,000 VKT × 0.5 L per VKT = 490 ×106 L of diesel (equation 7.5)

For the conversion of fuel consumption in volume units to energy units, the ministry staff use the default density and NCV values shown in Table 7.9:

$F_{gasoline,car,y}$ = 1,090,000,000 L × 720 kg/m^3 x 44.3 TJ/Gg ÷ 109 = 34,767 TJ (equation 7.6)

$F_{diesel,bus,y}$ = 490,000,000 L × 835 kg/m^3 × 43.0 TJ/Gg ÷ 109 = 17,593 TJ (equation 7.6)

Second, the ministry staff estimate the total fuel energy used for **rail passenger transport** (diesel and electric trains; step 2b). They ask the two operating rail companies in the capital city about the most recent data on diesel and electricity use. The companies report the following data (accumulated for both companies):

$FC_{diesel,rail,y}$ = 300 ×106 L of diesel

$FC_{electricity,rail,y}$ = 440,000 MWh

The ministry staff use the default density and NCV values to convert the fuel consumption in volume units to energy units, as shown in Table 7.9:

$F_{diesel,rail,y}$ = 300,000,000 L × 835 kg/m^3 × 43.0 TJ/Gg ÷ 109 = 10,772 TJ (equation 7.7)

$F_{electricity,rail,y}$ = 440,000 MWh × 0.0036 = 1,584 TJ (equation 7.8)

Under step 3 (Compile emission factors), the ministry staff choose to use the default values, since other values are not available. For the emission factor of electricity (national electricity mix), they decide to apply the factor for a conventional (i.e. fossil fuel) electricity mix, since the share of renewables is low:

$EF_{gasoline}$ = 69.3 tCO_2/TJ

EF_{diesel} = 74.1 tCO_2/TJ

$EF_{electricity}$ = 220.0 tCO_2/TJ

BOX **7.3,** continued

Example of calculation of base year emissions (values rounded) for approach C

Next, the ministry staff determine the base year emissions by applying step 4 (Calculate base year emissions for the selected year):

$BE_{gasoline,car,y}$ = 34,767 TJ × 69.3 tCO_2/TJ = 2,409,328 tCO_2 (equation 7.9)

$BE_{diesel,bus,y}$ = 17,593 TJ × 74.1 tCO_2/TJ = 1,303,675 tCO_2 (equation 7.9)

$BE_{diesel,rail,y}$ = 10,772 TJ × 74.1 tCO_2/TJ = 798,168 tCO_2 (equation 7.9)

$BE_{electricity,rail,y}$ = 1,584 TJ × 220.0 tCO_2/TJ = 348,480 tCO_2 (equation 7.9)

The ministry staff follow step 5 (Estimate PKM) to estimate PKM for all the passenger transport modes.

For road transport, PKM can be calculated according to the bottom-up travel activity data:

$PKM_{gasoline,car,y}$ = 10,900,000,000 VKT × 2 persons = 21,800 million PKM (equation 7.10)

$PKM_{diesel,bus,y}$ = 980,000,000 VKT × 16 persons = 15,680 million PKM (equation 7.10)

For rail transport, PKM cannot be derived separately for diesel and electricity. The operating rail companies report the total PKM (combined):

$PKM_{rail,y}$ = 18,000 million PKM

Starting from this combined value, the ministry staff calculate the share of rail PKM for diesel and electricity:

$PKM_{diesel,rail,y}$ = 18,000 million PKM × ((10,772 TJ × 0.3) ÷ ((10,772 TJ x 0.3) + (1,584 TJ × 0.9))) = 12,490 million PKM (equation 7.11)

$PKM_{electricity,rail,y}$ = 18,000 million PKM × ((1,772 TJ × 0.9) ÷ ((10,772 TJ × 0.3) + (1,584 TJ × 0.9))) = 5,510 million PKM (equation 7.11)

The next step is step 6 (Calculate ratio of total emissions per mode to PKM). This calculation allows the ministry staff to compare the emission efficiencies of the different modes:

$BEPKM_{gasoline,car,y}$ = 2,409,328,000,000 gCO_2 ÷ 21,800,000,000 PKM = 111 gCO_2/PKM (equation 7.12)

$BEPKM_{diesel,bus,y}$ = 1,303,675,000,000 gCO_2 ÷ 15,680,000,000 PKM = 83 gCO_2/PKM

$BEPKM_{diesel,rail,y}$ = 798,168,000,000 gCO_2 ÷ 12,489,902,406 PKM = 64 gCO_2/PKM

$BEPKM_{electricity,rail,y}$ = 348,480,000,000 gCO_2 ÷ 5,510,097,594 PKM = 63 gCO_2/PKM[35]

Thus, the result shows that there are approximately 4.86 $MtCO_2$ annual emissions in the base year with all the modes (passenger gasoline car, diesel bus, diesel train and electric train).

7.3.7 General considerations for estimating activity data for approach C

When assessing the activity data for approach C, it is important to keep in mind the assessment principles outlined in Chapter 4, particularly the principle of accuracy. The assessments done using approach C produce highly uncertain results for fuel use in passenger transport as a result of the following limitations:

- Uncertainties in parameter estimations (e.g. distance travelled) are major and have a large influence on the results of approach C.
- Using default values (e.g. average fuel consumption of vehicles, load factor, conversion factors) leads to further uncertainty.
- Approach C only accounts for gasoline consumption in passenger car transport (i.e. excludes diesel consumption).

[35] If the electricity mix contained more than 50% of electricity from renewable sources and the other option for the emission factor could have been chosen (110,000 $kgCO_2$/TJ), $BEPKM_{electricity,rail,y}$ would be approximately 32 gCO_2/PKM.

7.4 Develop a projection of baseline emissions

It is a *key recommendation* to develop a projection of baseline emissions for each year of the assessment period. Most calculation parameters identified in Sections 7.1 and 7.2 need to be projected into the future. By projecting the base year emissions, users can determine baseline emissions for a time series. Figure 7.7 provides an overview of steps for projecting baseline scenarios. These steps are addressed in this section.

Where the results of the assessment will be used to meet the reporting requirements of the transparency framework, users should consider aligning the parameters used for the emissions projections of transport pricing policies with those used to develop sectoral projections to meet relevant reporting requirements. It is recommended that users align the time frame used for the emissions projections of transport pricing policies with the time frame used for sectoral projections developed to meet the reporting requirements of the transparency framework (i.e. the starting and final year of the projections developed for transport pricing policies should be the same as the starting and final year of the transport sector projections).

7.4.1 Step 1: Determine the influence of other policies in the transport sector

This step comprises two substeps: determining the influencing policies, and determining the direction and significance of effects.

Step 1a: Determine influencing policies and actions

National strategies and goals influence policies that are likely to be implemented within the assessment period. They include general development strategies, NDCs, climate strategies and dedicated sector strategies, such as energy and transport strategies.

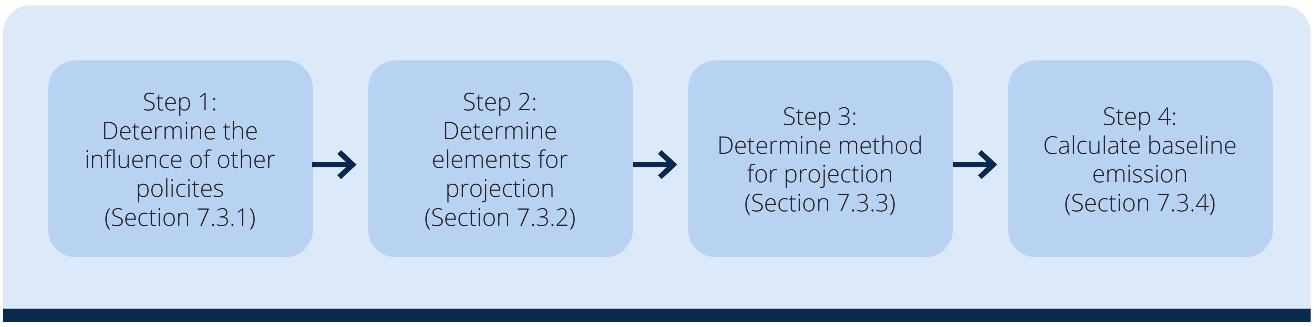
Users should assess the influence of policies (other than the one being assessed) on transport sector developments when projecting the baseline scenario. Some policies that are already implemented or under preparation will directly influence expected developments in the transport sector. This is particularly the case if they have been introduced recently and their effects have not yet had an influence on observed trends in the sector. As discussed in Section 5.2, users can decide to assess such policies together with the pricing policy as a package. In such cases, the impact of the other policies would not be considered here in determining the baseline. In all other cases, their impact should be part of the baseline.

Users who are assessing the sustainable development, transformational or other GHG impacts of a policy should use the same underlying assumptions about macroeconomic conditions, demographics and other non-policy drivers. For example, if gross domestic product (GDP) is a macroeconomic condition needed for assessing both the job impacts and the economic development impacts of a buildings policy, users should use the same assumed value for GDP over time for both assessments.

Users projecting transport sector emissions should consider several dimensions that can be influenced by existing or planned policies, but also by other

FIGURE **7.7**

Overview of steps for projecting baseline emissions



factors. In particular, technology innovation can be a critical factor influencing baseline developments. It is important to consider not only the most obvious policies, but also policies outside the transport sector. A few examples are provided in Table 7.12.

Step 1b: Determine direction and magnitude of effects

The more detailed the assessment method, the more detailed the analysis of the influence of other policies should be. The main question relating to the effect of other policies is whether their influence on expected developments mainly leads to a continuation of past trends or to a shift from past trends. If the general assessment is that these policies impact the trend, the next question is in which direction, by how much (magnitude) and the likelihood of influence. The magnitude and likelihood of effects will determine how appropriate a simplified and/or econometric method is for the assessment, and how much the results of such methods need to be adjusted to reflect implemented (or planned) policies (other than the one being assessed) in projecting the baseline.

The direction of effects needs to be determined based on expert knowledge and a logical chain of effects that impact relevant parameters. For lower-accuracy methods (approaches A and B), the magnitude can be determined using a rule of thumb, based on literature or experiences in other countries; this is illustrated in Table 7.13, using the relative magnitude of effects (i.e. how a policy is likely to change observed or expected trends). For more detailed methods, effects should be determined using more elaborate methods.

An example is as follows: If car ownership per capita has increased by 2% per year in recent years, the question is whether policies can be expected to change this trend. For example, a new import regulation that aims to prevent old, inefficient and unsafe vehicles from being imported could slow this trend, because fewer people would be able to afford a car. The magnitude of impact on the vehicle fleet and resulting fuel use depends on a number of factors, including the relevance of imported vehicles targeted by the policy, price differences compared with vehicles not affected by the policy and the detailed design of the policy. Effects would be considered major if, for example, the expected impact would reduce the growth rate of vehicle ownership to 1.7% (a relative magnitude of 15%). The same principle applies in cases where trends are more rapid, such as with an annual growth rate of 70%. Here, a policy that is expected to change the trend by 0.7 percentage points to 70.7% annual growth would be considered minor (a relative magnitude of 1%), whereas a 15% change in relative magnitude to 80.5% annual growth would be considered major.

TABLE **7.12**

Examples of policies influencing transport sector developments

Dimension	Examples
Maintenance and operation, and investment in new infrastructure	• Changes in responsibilities (e.g. privatization of infrastructure or services) may result in different levels of investment. • Programmes to support economic growth in certain sectors can lead to enhanced infrastructure investment.
New technologies entering the market	• Incentive programmes (e.g. to promote electric vehicles or biofuels) may influence adoption of new technologies. • Changes in import regulation may change prices and availability.
Technology improvements	• Health and safety measures (e.g. introduction of mandatory regular vehicle inspection) can influence the age structure and thus the overall efficiency of the fleet. • National fuel efficiency standards can influence vehicle technology.
Development of customer preferences	• Awareness-raising measures and education can increase environmental concerns.

TABLE **7.13**

Assessing the relative magnitude of impacts of other policies

Relative magnitude of impacts	Description	Approximate relative magnitude (rule of thumb)
Major	The policy significantly influences one or more of the trends in transport sector development. The resulting change in relevant parameters is likely to be a significant change from current status and past trends.	>10%
Moderate	The policy influences one or more of the trends in transport sector development. The resulting change in relevant parameters could lead to significant changes from current status and past trends.	1–10%
Minor	The policy has little or no influence on the expected developments in the transport sector. The change in parameter values is insignificant.	<1%

Source: Adapted from WRI (2014).

Different policies may influence the same parameters within the transport sector. The effects can be reinforcing, overlapping or independent. The relative magnitude of effects should be determined for each policy separately. This involves identifying the parameters that are most likely to be affected and estimating the relative magnitude of the effect for each.

7.4.2 Step 2: Determine elements for projection

Population and economic growth have a large influence on the transport sector. They are considered primary factors and will in most cases directly impact the activity parameters needed for calculation. Thus, projections usually account for expected trends in population and GDP. Users should determine baseline scenario projections based on expected changes in population and GDP.

Secondary influencing factors (e.g. car ownership rates, technological development, cost, availability of transport alternatives) may be valuable additional factors for the impact assessment, provided they can be monitored.[36]

Table 7.14 provides an overview of the data categories that need to be projected and which of these are influenced by population, GDP or other factors.

For approaches A and B, fuel use is influenced by population and economic growth, whereas emission factors are independent. For approach C, population growth will likely affect the number of trips taken and potentially the distance travelled (e.g. through urban sprawl). Economic growth also influences the number of trips, distance travelled and fleet composition; thus there is a strong influence of population and/or GDP. Users should make projections based on the per capita or per GDP ratios of parameters to allow meaningful projections.

[36] Secondary factors can be directly influenced by primary factors – for example, car ownership is usually correlated with population and/or GDP. Monitoring and quantifying secondary factors might be difficult (e.g. the impact of technological development is difficult to measure).

TABLE **7.14**

Influence of population and GDP on data categories

Category of data	Projection necessary for simplified method (Section 7.4.3)	Projection necessary for advanced methods (Section 7.4.3)	Influenced by		
			Population	GDP	Other
Approaches A and B					
Fuel use	Yes	Yes	Major	Moderate	
Emission factors per fuel	No Constant values[a]	No Constant values			
Approach C					
Carbon content	No Constant values	No Constant values			
Fleet composition	No	Yes	No	Major	
Distances travelled (VKT)	Yes	Yes	Minor	Moderate	
Trips	No	Yes	Major	Minor	
Load factor	No	Yes	Moderate	Minor	Attractiveness, cost, availability
Fuel consumption	No	Yes	No	No	Technological development

Abbreviation: VKT, vehicle kilometres travelled

[a] Emission factors for each fuel type are mainly determined by the carbon content of the fuel.

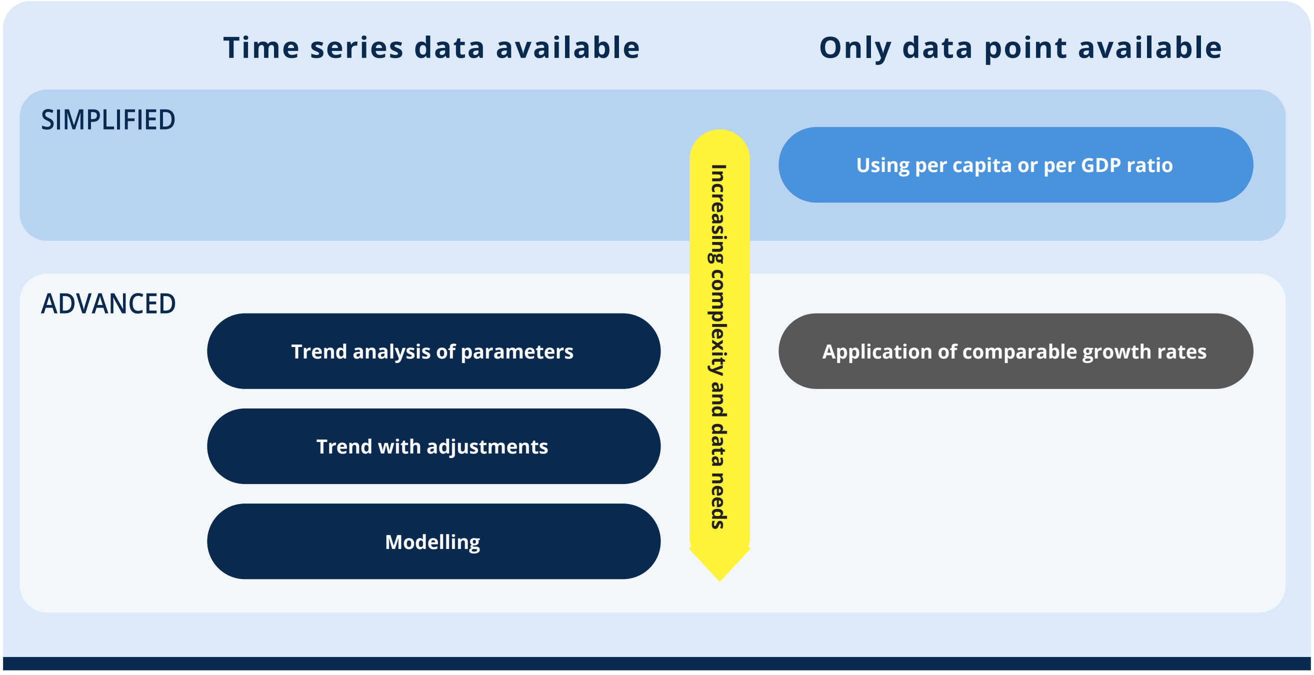
7.4.3 Step 3: Determine method for projection

Different methods are available to project individual parameters and overall emissions. They vary in their level of complexity and in data requirements, as illustrated in Figure 7.8. The choice of method fundamentally depends on the input data available. It is preferable to build a baseline from a time series. If a time series is available, statistical methods should be used to determine trends. These trends can be adjusted to reflect the analysis of the expected influence of other policies, as discussed above. The most complex method is transport sector modelling, which integrates these effects and reflects interlinkages between different system elements.

If a time series is not available, a single data point can be used. In this case, the results produced will be less robust. If available, a multi-year average may make the results more robust. However, in many countries where only one data point is available, a less robust approach may be sufficient. In such cases, the per capita or per GDP ratio (intensity) of parameters can be used, together with assumptions about the future development of population and GDP. Alternatively, users can apply trends from comparable sources, such as neighbouring countries at a similar stage of development, or with similar transport systems and growth patterns.

FIGURE **7.8**

Overview of methods for projection



7.4.4 Step 4: Calculate baseline emissions

In step 4, calculate emissions for each year based on projected parameter values, using the methods in Sections 7.1 and 7.2 (modelling based on the factors identified in Section 7.4.1). Apply the selected method to the relevant parameters for all years of the assessment period. The next two sections provide detailed methods for performing calculations using simplified and advanced methods.

Option 1: Simplified method for projecting scenarios

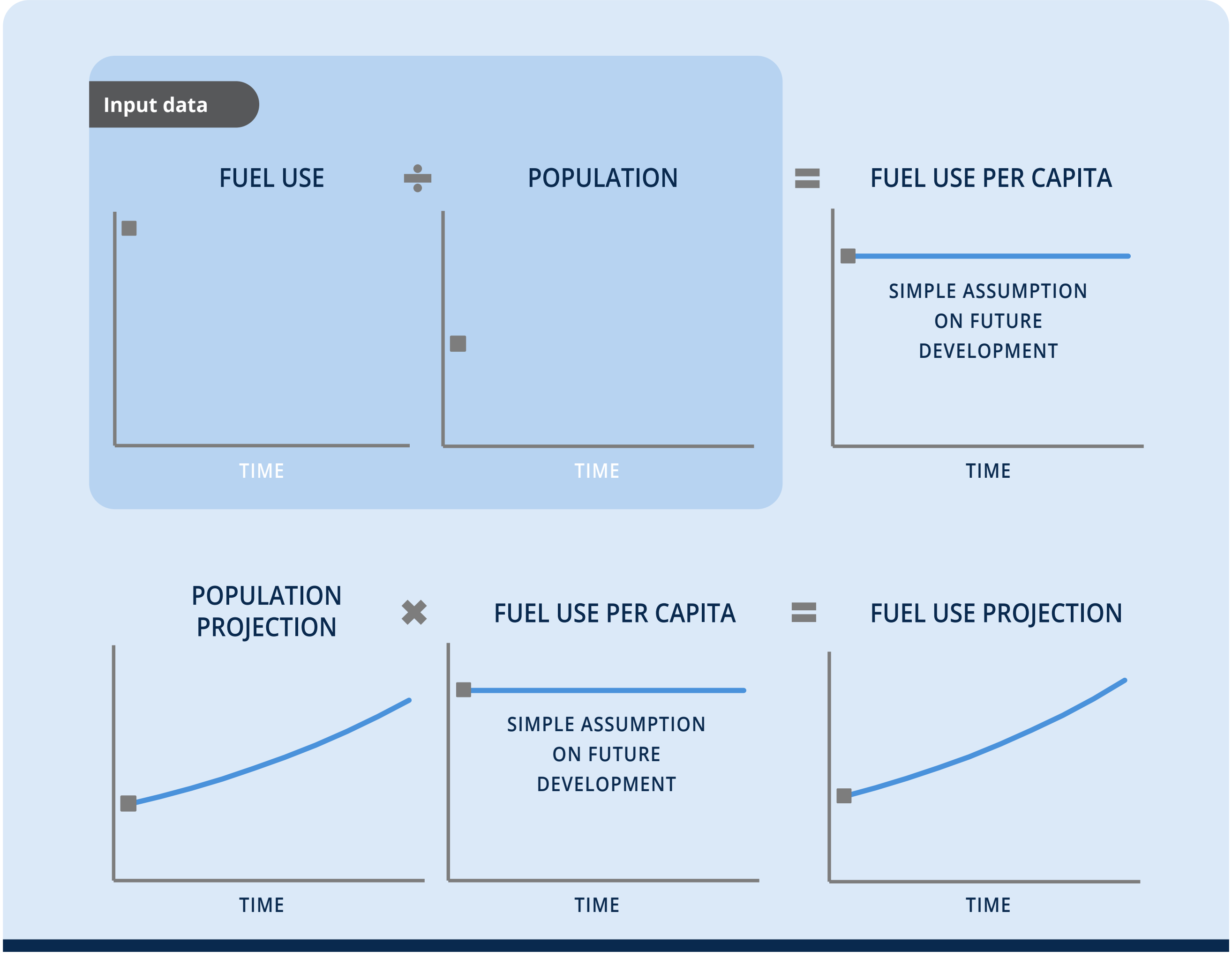
Based on the strong relationship between population and/or GDP and some of the key parameters for calculating emissions, per capita values or intensities can provide a good basis for projections. In particular, this is a useful approach where data for only one year are available.

The simplest way of projecting parameter values into the future is to select the main driving factor for a parameter (e.g. population or GDP) and assume a constant development over time, as illustrated in Figure 7.9, which uses approach A and projects fuel use based on expected population development. Current fuel use per capita can be calculated using known data on fuel use and population. The simplest assumption is that per capita fuel use will remain constant.

More sophisticated methods may include the impact of GDP on the same parameter – for example, through the use of income elasticities as a means to predict travel demand as a function of increasing income (see also section on trends with adjustments below).

FIGURE **7.9**

Simplified approach to projecting parameters using population projections



Box 7.4 provides possible sources for projections of population and GDP, and Box 7.5 provides an example illustrating the simplified method for projecting scenarios using approach A. Templates of the tables used in this example can be found in Chapter 12 (Table 12.3), where users can report on the data collected and used for calculations in this section.

Option 2: Advanced methods for projecting scenarios

Application of comparable growth rates

Assuming constant absolute values is in most cases an oversimplification of expected real developments. Using per capita values or intensities addresses this to some extent, but still falls short of real-world developments, particularly since more than one factor usually influences the parameter.

Growth rates based on relevant literature or data from comparable settings can help to incorporate some of the complexities of the different influences on a parameter in the absence of available time-series data that would deliver trends specific to the assessed situation.

BOX **7.4**

Sources for population and GDP projections

Projections for population and GDP are important elements in determining transport sector baseline scenarios. Providing methodologies for projecting these parameters is outside the scope of this methodology. Robust projections are usually available from a range of sources. The most widely used include the following.

Population

- National statistics offices or similar agencies normally provide detailed country-level projections.
- The United Nations Department of Economic and Social Affairs Population Division regularly publishes the World Population Prospects (https://population.un.org/wpp).
- The World Bank produces population estimates and projections (https://databank.worldbank.org/source/population-estimates-and-projections).

GDP

- National statistics offices, economic or development ministries, or similar agencies produce projections for GDP.
- The International Monetary Fund regularly publishes the World Economic Outlook, including projections on key financial indicators, such as GDP (currently until 2021) (www.imf.org/en/data).
- The World Bank recently published the *Global Economic Prospects* (forecasts available until 2019) (www.worldbank.org/en/publication/global-economic-prospects).

BOX **7.5**

Example of simplified method for projecting scenarios using approach A

A government plans to implement a national fuel levy on gasoline and diesel. The ministry decided to use approach A (step 1). They have already estimated the baseline emissions for the current year *y* (according to Section 7.2.1). As the next step, they plan to project the base year result to the years between *y* + 1 and *y* + 5.

The ministry staff start with step 2 (Determine elements for projection). They decide to use the simplified method to project scenarios, because of low data availability. Therefore, they keep the emission factors for fuels constant and only apply a projection to the fuel use.

In step 3 (Determine method for projection), the ministry staff choose a simple method. They use the per capita ratio of the fuel-use parameter to extrapolate the future fuel use according to population trends.

Finally, the ministry staff perform the calculations in step 4 (Calculate baseline emissions). From their earlier calculations (see Box 7.1), they know the fuel consumption in the current year:

F_y = 782,000 TJ, of which 50% is gasoline and 50% is diesel

In the simplified method, they keep emission factors constant for the projection (see Box 7.1):

$EF_{gasoline}$ = 74.1 tCO_2/TJ; EF_{diesel} = 69.3 tCO_2/TJ

Finally, they collect the current population data from the most recent statistics. In the year *y*, the country has 50 million inhabitants. Hence, the per capita ratio of the fuel consumption in year *y* can be calculated:

Per capita ratio gasoline consumption = (782,000 TJ × 50%) / 50,000,000 = 7.8 GJ gasoline per capita

Per capita ratio diesel consumption = (782,000 TJ × 50%) / 50,000,000 = 7.8 GJ diesel per capita

The ministry staff assume that the population will grow by 1.5% every year. Now, they have collected all the data they need for the calculation (see table below).

They find the total gasoline and diesel consumption by multiplying the per capita ratio by the projected population numbers:

For example, for year *y* + 1, $F_{gasoline,y}$ = 7.8 GJ/capita (per capita ratio) × 50.8 persons (population in year *y* + 1)

From this point, the ministry staff calculate baseline emissions ($BE_{i,y}$) by multiplying with the respective emission factor, and then summing emissions from gasoline and diesel combustion.

BOX **7.5**, continued

Example of simplified method for projecting scenarios using approach A

	Unit	Year *y* (historical)	Year *y* + 1	Year *y* + 2	Year *y* + 3	Year *y* + 4	Year *y* + 5
Population (in millions)	million	50.0	50.8	51.5	52.3	53.1	53.9
Per capita ratio: gasoline consumption	GJ per capita	7.8	7.8	7.8	7.8	7.8	7.8
Per capita ratio: diesel consumption	GJ per capita	7.8	7.8	7.8	7.8	7.8	7.8
$F_{gasoline,y}$ (projected)	TJ	391,000	396,865	402,818	408,860	414,993	421,218
$F_{diesel,y}$ (projected)	TJ	391,000	396,865	402,818	408,860	414,993	421,218
$BE_{gasoline,y}$ (projected)	$ktCO_2$	27,096	27,503	27,915	28,334	28,759	29,190
$BE_{diesel,y}$ (projected)	$ktCO_2$	28,973	29,408	29,849	30,297	30,751	31,212
$BE_{total,y}$ (projected)	$ktCO_2$	56,069	56,910	57,764	58,631	59,510	60,403

In the above example, historical average growth rates established for a similar country, region or city could be used to determine the projected fuel use per capita. Instead of having a constant value, this parameter would increase over time using the following equations:

$$\text{Fuel use per capita in year 2} = \text{fuel use per capita in historical data year} \times (1 + \text{growth rate})$$

$$\text{Fuel use per capita in year 3} = \text{fuel use per capita in year 2} \times (1 + \text{growth rate})$$

Applying a growth rate of 3%, this would result in the following values:

$$\text{Fuel use per capita in year 2} = 0.0001 \text{ TJ per capita} \times (1 + 0.03) = 0.000103 \text{ TJ per capita}$$

$$\text{Fuel use per capita in year 3} = 0.000103 \text{ TJ per capita} \times (1 + 0.03) = 0.00010609 \text{ TJ per capita}$$

Trend analysis

A trend is a statistical method that is often used to understand past developments. Under the assumption that certain parameters are most likely to develop in the same way as in the past, the trend is often extrapolated into the future. However, the trend does not necessarily constitute the most likely scenario for all relevant variables in the determination of a baseline scenario. Trend analysis requires a time series of data for the relevant parameters. There are two types of trends:

- **Linear trends** represent the extrapolation of historical developments (trend) into the future in the form of a linear increase or decrease in parameters. This technique is often used to extrapolate the historical development of vehicle efficiency (also called autonomous technology development). Constant growth rates lead to linear trends.

- **Non-linear trends** are usually captured using more complex models, but can also be found in simplified calculations. Typical non-linear effects include
  - » learning curves, with a slow effect at the beginning, then more rapid take-up and saturation after a certain time
  - » exponential growth functions
  - » developments based on bottom-up data, such as detailed transport sector planning models. Here, planned impact of investments can lead to sudden changes in parameters away from previous trends.

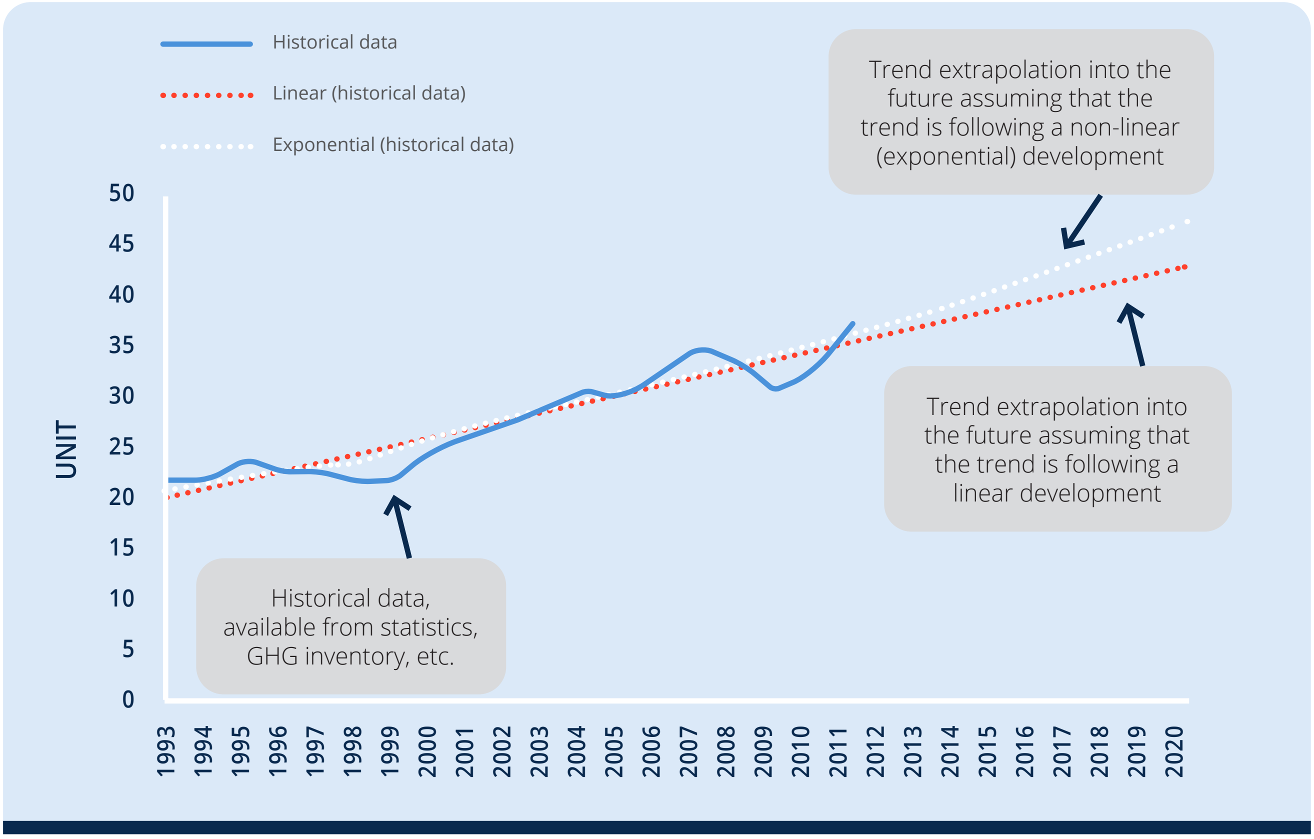
Figure 7.10 illustrates the projection of parameters using linear and non-linear trends.

How well a trend represents likely future developments depends on a number of factors, including the following:

- **Available number of data points.** Although two or three data points can be seen to represent a time series, they do not allow a meaningful trend analysis. In principle, the more data points, the better. With older data, consistency with newer data needs to be ensured, as data-collection methods, definitions or scope may have changed over time.
- **Fluctuations in the time series.** Most parameters do not develop according to a clear curve. Values change from year to year, because they are influenced by a wide range of factors. The larger and more unpredictable these fluctuations, the less a trend will represent likely developments. For example, population normally has a relatively uniform development, with very limited fluctuations. GDP, on the other hand, shows frequent and

FIGURE **7.10**

Projecting parameters using linear and non-linear trends



strong fluctuations that make it challenging to determine a trend and project future GDP development.

- **Expected changes in fundamental drivers.** As discussed above, policies can influence the underlying drivers of individual parameters. Policies can also be influenced by innovations or disruptive events. The invention of the car, for example, fundamentally changed mobility patterns in the early 1900s. Natural catastrophes, such as earthquakes or hurricanes, and war can significantly impact developments. Although there is little we can do to capture natural and human-caused catastrophes in projections, the next section discusses how to factor in some of the developments we can foresee.

Trend with adjustments
To add another layer of analysis to the trend, the influence of policies and other factors can be incorporated. To do this, the trend is first determined and then adjusted based on the analysis of the influencing factors, as described in Section 7.4.1, using a simple method:

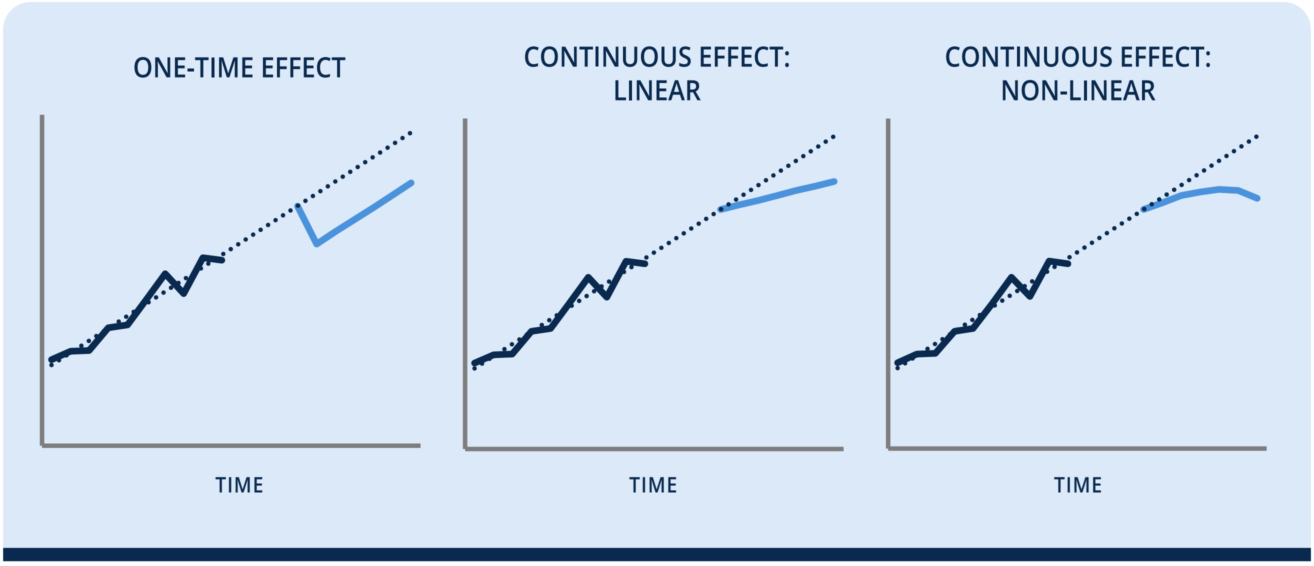
1. **Determine starting point of effect.** This could be the point in time when a policy is expected to enter into force or the planned end of construction for a larger infrastructure project. Effects can also be staged – for example, if construction contains separate phases that come into operation at different times. The starting point can also be the start point of the assessment, if policies are already in place, but are not yet expected to affect the observed trend.

2. **Translate qualitative assessment into quantitative effect.** The main question is whether the effect is
   - a one-time effect – that is, it changes the value of the trend for the year when it occurs and then continues the trend from that new value
   - a continuous effect – that is, effects keep influencing the parameter and lead to a complete deviation from the trend. Like the trend itself, the deviation can be linear or non-linear. The application of a learning curve, for example, to reflect autonomous technology improvement, would be a classical example of a continuous, non-linear effect. The value for change should be determined based on expert judgment and, where available, experiences from other countries, regions or cities.

3. **Apply to trend.** Once the type of the effect is identified and its magnitude is quantified, this can be applied to the trend, as illustrated in Figure 7.11.

FIGURE **7.11**

Trend adjustment for different effects



Modelling

Models apply many of the methods explained above and can in most cases also compute interrelationships between different parameters. They may be built on the actual transport infrastructure of a defined geographic area and are mostly used for transport planning. Other models represent the transport system through the parameters discussed above, in terms of fleet composition or distances travelled. Possible tools and models that can be used include:

- United Nations Environment Programme *A Toolkit for Preparation of Low Carbon Mobility Plan* – provides a detailed description of how to model transport demand based on travel characteristics[37]
- Cube – software for modelling and simulation of traffic and land use[38]
- Energy and Emissions Reduction Policy Analysis Tool – an integrated, state-level modelling system designed specifically to evaluate strategies for reducing transportation energy consumption and GHG emissions[39]
- Motor Vehicle Emission Simulator (MOVES) – estimates emissions for mobile sources at the national, country and project levels[40]
- TransCAD – provides GIS-based travel demand modelling.[41]

Models require the most detailed level of data and are only feasible to use with approach C.

[37] Available at: www.uncclearn.org/sites/default/files/inventory/a_toolkit_for_lcmp.pdf.

[38] Available at: www.citilabs.com/software/cube.

[39] Available at: https://cleanenergysolutions.org/es/resources/energy-emissions-reduction-policy-analysis-tool.

[40] Available at: www.epa.gov/moves.

[41] Available at: www.caliper.com/tctraveldemand.htm.

8 Estimating GHG impacts ex-ante

This chapter describes how to estimate the expected future GHG impacts of higher fuel prices. This requires an understanding of the policy scenario, which is the scenario that represents the events or conditions most likely to occur in the presence of the policy (or package of policies) being assessed. Users estimate policy scenario emissions for the GHG sources included in the GHG assessment boundary. The GHG impact of the policy is estimated by subtracting baseline emissions (as determined in Chapter 7) from policy scenario emissions. Users estimating ex-post GHG impacts only can skip this chapter and proceed to Chapter 9.

Checklist of key recommendations

- Use country-specific price elasticity data, if available, and otherwise use default price elasticity values
- Calculate the GHG impacts of the policy using appropriate parameter values and equations
- Carefully interpret the results, including assessing uncertainty and the GHG impacts of use of revenues from the policy

8.1 Choose price elasticity values

8.1.1 Introduction to price elasticities

Ex-ante impacts are assessed using specific price elasticity values to predict changes in transport demand and GHG emissions reductions compared with the projected baseline emissions obtained in Chapter 7. Pricing policies increase the fuel price, either by adding a tax or levy, or by removing an existing subsidy on the fuel (see Section 3.1). These price changes influence the demand for fuel.

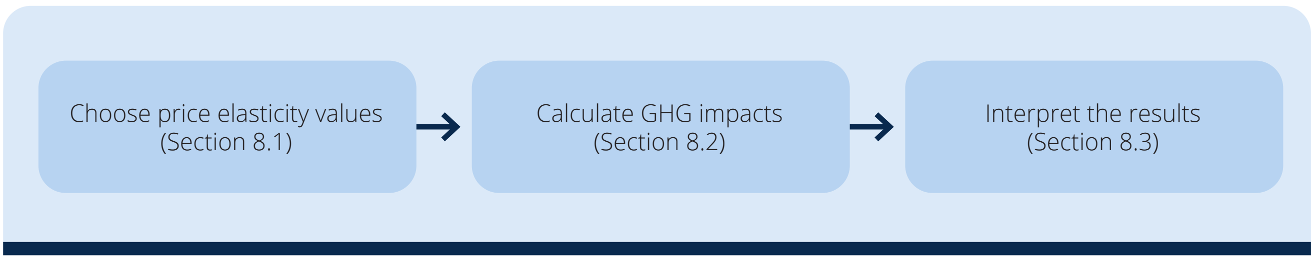
The own-price elasticity is the percentage change in a good's demand divided by the percentage change in that good's price. Own-price elasticities quantify how fuel demand changes when fuel prices rise. The own-price elasticity is used to estimate the direct impact, or the net effect, of a fuel price increase on fuel demand.

The cross-price elasticity is the percentage change in a good's demand divided by the percentage change in a substitute good's price. Cross-price elasticities quantify how the demand for other transport modes changes when fuel prices rise (i.e. mode shift). The cross-price elasticity is used to estimate the indirect impact, or the gross effect, of a fuel price increase on transport demand in alternative modes.

Box 8.1 provides an example calculation for both own-price elasticity and cross-price elasticity.

FIGURE **8.1**

Overview of steps in the chapter



BOX **8.1**

Examples of own-price elasticity and cross-price elasticity[42]

Own-price elasticity

Price changes by +10%; demand changes by –5%; price elasticity of demand equals demand change divided by price change: –5%/+10% = –0.5.

Cross-price elasticity

Price of substitute good changes by +10%; demand changes by +20%; cross-price elasticity of demand equals demand change divided by price change: +20%/+10% = +2.

Fuel price increases due to a policy can lead to the following major impacts:

- reduced vehicle travel
- increased number of passengers per vehicle (load factor)
- increased switching to more efficient and alternative-fuel vehicles
- increased switching to other transport modes.

The net impact of a fuel price change is a reduced fuel demand and subsequent emissions reductions from transport fuel use. However, a fraction of this reduction will be compensated for by higher demand and emissions from other modes, due to mode shifts.

It is a *key recommendation* to use country-specific price elasticity data, if available, and otherwise use default price elasticity values. Sections 8.1.2, 8.1.3 and 8.1.4 provide guidance for price elasticity data for each of approaches A, B and C.

Elasticity data are generally collected using empirical methods. Empirically collected elasticity data from different sources can be analysed using statistical approaches. Patterns in the data allow users to interpolate elasticities according to specific parameters. For fuel price elasticities, such parameters include fuel price and mean income per capita. Two types of equations are used to analyse empirically collected elasticity values:

- **Static equations** do not temporally distinguish elasticity values and only provide one estimate. The static approach does not account for temporal effects such as time lag, whereas the estimation of elasticities with a dynamic approach does account for temporal effects, and tests for time lag using lagged and non-lagged variables.

- **Dynamic equations** can distinguish between short-run and long-run elasticity effects, since they take temporal effects into account. Short-run price impacts tend to be less elastic than long-run impacts.[43] Long-run elasticity values are elasticity values from static models or long-run elasticity estimates from dynamic models. There is no consensus about how price elasticity estimates should be classified. In some studies, they are categorized as intermediate run; in others as long run. However, more recent literature tends to interpret static elasticity estimates as long run.[44]

More than 200 references on fuel price elasticities have been analysed.[45] These values form the basis for the default elasticity values presented in

[42] The description in the box is simplified. The exact estimation of price elasticities of demand is done with a logarithmic equation. That is, when Q is the demand and P is the price, the elasticity $\varepsilon = \Delta\ln(Q) / \Delta\ln(P) = (\Delta Q/\Delta P) \times (Q/P) = (\Delta Q/Q) / (\Delta P/P)$, which is a percentage change in the demand when the price changes by 1%. This value needs to be multiplied by the actual percentage change in the price to determine the actual percentage change in demand due to the price change determined by the pricing policy.

[43] For example, if a pricing policy is perceived by the public as a long-run effect on the price (the policy is considered to be persistent), it will lead to rather elastic reactions by consumers. If price changes are only market induced, the price change will not be considered as persistent, and reactions will be less elastic.

[44] Dahl (2012).

[45] Dahl (2012).

Sections 8.1.2, 8.1.3 and 8.1.4. They can be used to estimate the impact of a policy using approaches A, B and C. Sections 8.1.2, 8.1.3 and 8.1.4 are only relevant if no country-specific elasticity values are available. Where applicable and validated country-specific elasticity values are available, users should skip to Section 8.2.

It is very important to be aware that price elasticity values depend on the actual price change – for example, the price elasticity for gasoline will not be the same for a price increase of 1% as for a price increase of 500%. In this methodology, the default elasticity values are based on empirical studies completed within the past five decades. Hence, they take into account fuel price changes in the past (averaged for different countries and for different price increase scales). Users should follow Section 8.3 and calculate a range of possible results to take these uncertainties into account.

8.1.2 Price elasticities for approach A

The approach A default price elasticities for an unspecified fuel mix ($\varepsilon_{fuel\ mix}$) are provided in Table 8.1. The simple method provided in approach A should only be used when limited data are available. Approach B should be applied where it is known or assumed that freight transport is predominantly powered with diesel fuel.

The default price elasticity values for approach A are based on the following assumptions:

- Fuel price elasticities at the national level depend on average income per capita and fuel prices. Fuel price elasticities change only marginally over time and can be revised for different years using the consumer price index (CPI) and the purchasing power parity (PPP) index. When applying a CPI correction to fuel prices and income per capita, the values provided by Dahl (2012) are currently valid and are expected to continue to be valid in the future.
- Fuel price elasticities are expected to be similar for a broad range of price increases.
- Where fuel shares (e.g. gasoline, diesel) are unknown, gasoline price elasticity values are the best estimates for assessing impacts on the unknown fuel mix.

Table 8.1 shows prices and incomes per capita in US dollars (or cents) for the year 2016. For every new assessment, the ranges of prices (e.g. fuel mix price ≤30 cents) and incomes per capita (e.g. income per capita ≥$24,000) should be adjusted to the year of the assessment. To find the accurate elasticity values in Table 8.1, follow these three steps:

1. Collect data for actual fuel prices (annual average) and income per capita (annual average) in the local currency for the year of the assessment (most recent year with available data).
   Data requirements:
   a. Actual **fuel price** (annual average) in local currency for the assessment year
   b. Actual **per capita income** (annual average) in local currency for the assessment year
2. Convert the local fuel price (annual average) and income per capita (annual average) with PPPs. Use the PPP conversion factors (local currency unit – LCU – per international $) for the year of the assessment.[46]
   Calculation:
   a. Fuel price from step 1a ÷ $\text{PPP}_{\text{conversion factor for the year of assessment}}$
   b. Per capita income from step 1b ÷ $\text{PPP}_{\text{conversion factor for the year of assessment}}$

TABLE **8.1**

Default fuel mix price elasticity values ($\varepsilon_{fuel\ mix}$) for approach A (national level)

Fuel mix price (2016 cents per litre)	Income per capita (2016 $)[a]		
	≤12,000	12,000–24,000	≥24,000
≤30	–0.15	–0.11	–0.22
30–80	–0.22	–0.24	–0.22
≥80	–0.26	–0.32	–0.33

Source: Values adapted from Dahl (2012).
[a] The per capita income ranges are based on the best available data source for building a model of elasticities that is applicable worldwide for developing countries. Use of country-specific data, if available, is strongly recommended.

[46] World Bank (2019a).

Results:

a. Fuel price (annual average) in US$ for the assessment year, adjusted to PPP

b. Local per capita income (annual average) in US$ for the assessment year, adjusted to PPP

3. Adjust the ranges of fuel price (e.g. fuel mix price ≤30 cents) and income per capita (e.g. income per capita ≥$24,000) in the tables above according to the US CPI between the year 2016 and the year of the assessment.[47] Calculation:

a. (US CPI $_{\text{for the year of assessment}}$ ÷ US CPI $_{2016}$) × fuel price from tables above (e.g. fuel mix price ≤30 cents)

b. (US CPI $_{\text{for the year of assessment}}$ ÷ US CPI $_{2016}$) × per capita income from tables above (e.g. income per capita ≥$24,000)

The results of these three steps are new ranges of fuel prices and per capita incomes for the tables. The elasticity values do not change, but they are now valid for the adjusted ranges of prices and incomes. Users can now apply the PPPs of the local fuel price and income per capita to the adjusted price elasticity tables to find the accurate default price elasticities.

Box 8.2 provides an example illustrating the choice of default price elasticities for approach A.

8.1.3 Price elasticities for approach B

The approach B default price elasticities for gasoline ($\varepsilon_{gasoline}$) and diesel (ε_{diesel}) fuel consumption are shown in Tables 8.2 and 8.3, respectively.

The default price elasticity values for approach B are based on the following assumptions:

- Gasoline and diesel price elasticities at the national level depend on average income per capita and fuel prices.
- Fuel price elasticities change only marginally over time and can be revised for different years using the respective CPI. When applying a CPI correction to fuel prices and income per capita, the values provided by Dahl (2012) are currently valid and are expected to continue to be valid in the future.
- Fuel price elasticities are similar for a broad range of price increases.

TABLE **8.2**

Default gasoline price elasticity ($\varepsilon_{gasoline}$) values for approach B (national level)

Gasoline price (2016 US cents per litre)	Income per capita (2016 $)		
	≤12,000	12,000–24,000	≥24,000
≤30	−0.15	−0.11	−0.22
30–80	−0.22	−0.24	−0.22
≥80	−0.26	−0.32	−0.33

Source: Values adapted from Dahl (2012).

BOX **8.2**

Example of choosing default price elasticities for approach A

A country decides to apply the default elasticity values, since no domestic studies are available and there is insufficient capacity to conduct a study. The country has a mean average income of $13,000 per capita and an annual mean fuel price of $0.50 per litre in 2016.

The default price elasticity value is $\varepsilon_{fuel\ mix}$ = −0.24.

[47] World Bank (2019b).

TABLE **8.3**

Default diesel price elasticity (ε_{diesel}) values for approach B (national level)

Diesel price (2016 US cents per litre)	Income per capita (2016 $)	
	≤18,000	≥24,000
≤ 80	−0.22	−0.13
≥ 80	−0.38	−0.27

Source: Values adapted from Dahl (2012).

The tables above reflect prices and incomes per capita in US dollars (or cents) for the year 2016. For every new assessment, the ranges of prices (e.g. diesel price ≥80 cents) and incomes per capita (e.g. income per capita ≥$18,000) should be adjusted to the year of the assessment. To find the accurate elasticity values in the above tables, follow these three steps:

1. Collect data for actual fuel prices (annual average) and income per capita (annual average) in the local currency for the year of the assessment (most recent year with available data).
   Data requirements:
   a. Actual **fuel price** (annual average) in local currency for the assessment year
   b. Actual **per capita income** (annual average) in local currency for the assessment year
2. Convert the local fuel price (annual average) and income per capita (annual average) with PPPs. Use the PPP conversion factors (LCU per international $) for the year of the assessment.[48]
   Calculation:
   a. Fuel price from step 1a ÷ $PPP_{\text{conversion factor for the year of assessment}}$
   b. Per capita income from step 1b ÷ $PPP_{\text{conversion factor for the year of assessment}}$

   Results:
   a. Fuel price (annual average) in US$ for the assessment year, adjusted to PPP
   b. Local per capita income (annual average) in US$ for the assessment year, adjusted to PPP
3. Adjust the ranges of fuel price (e.g. diesel price ≥80 cents) and income per capita (e.g. income per capita ≥$18,000) in the tables above according to the US CPI between the year 2016 and the year of the assessment.[49]
   Calculation:
   a. ($\text{US CPI}_{\text{for the year of assessment}}$ ÷ US CPI_{2016}) × fuel price from tables above (e.g. diesel price ≥80 cents)
   b. ($\text{US CPI}_{\text{for the year of assessment}}$ ÷ US CPI_{2016}) × per capita income from tables above (e.g. income per capita ≥$18,000)

The results of these three steps are new ranges of fuel prices and per capita incomes for the tables. The elasticity values do not change, but they are now valid for the adjusted ranges of prices and incomes. Users can now apply the PPPs of the local fuel price and income per capita to the adjusted price elasticity tables to find the accurate default price elasticities.

Box 8.3 provides an example illustrating the choice of default price elasticities for approach B.

8.1.4 Price elasticities for approach C

In contrast to approaches A and B, approach C includes not only fuel own-price elasticities ($\varepsilon_{gasoline}$), but also cross-price elasticities ($\varepsilon_{cross,j}$) that address the demand for other transport modes *j*. Approach C is specifically restricted to passenger transport on road and rail, including passenger cars, passenger buses and passenger rail. Therefore, approach C does not replace approaches A or B, but can be conducted in addition for a more detailed analysis.

The default own- and cross-price elasticity values for approach C are based on the following assumptions:

- Gasoline price elasticities at the national level depend on average income per capita and fuel prices.

[48] World Bank (2019a).

[49] World Bank (2019b).

BOX **8.3**

Example of choosing default price elasticities for approach B

A country decides to apply the default elasticity values, since no domestic studies are available and there is no capacity to conduct a study. The country has a mean average income of $13,000 per capita and an annual mean fuel price of $0.50 per litre in 2016.

The default gasoline price elasticity value is $\varepsilon_{gasoline}$ = –0.24.

The default diesel price elasticity value is ε_{diesel} = –0.22.

- Gasoline price elasticities change only marginally over time and can be revised for different years using the respective CPI. When applying a CPI correction to fuel prices and income per capita, the values provided by Dahl (2012) are currently valid and are expected to continue to be valid in the future.
- Gasoline price elasticities are similar for a broad range of price increases.
- In terms of transport demand, cross-price elasticities show similar patterns to own-price elasticities. That is, if the gasoline demand becomes more elastic (i.e. higher own-price elasticity) with increasing income per capita, demand for other passenger transport modes also becomes more elastic, thereby increasing the frequency of mode shifts. Therefore, the scaling of price elasticities described in Tables 8.2 and 8.3 can also be used as a proxy for cross-elasticities.

The own-price gasoline elasticities are shown in Table 8.4. The cross-price gasoline elasticities for shifts to bus and rail passenger transport are shown in Table 8.5.

For bus and rail, this methodology focuses on public transport vehicles. Buses are restricted to large, diesel-powered vehicles (average of 40 seats). Rail systems can include both diesel- and electricity-powered trains, and the analyses can include cable cars, street cars, tramways, metro, commuter rail, light rail and heavy rail.

For the estimation of cross-price elasticities, values from the United States[50] were used as a baseline. Starting from the baseline, the elasticities for different gasoline prices and per capita incomes were estimated using the same patterns between the elasticity values, the gasoline price and the income per capita as in Dahl (2012). See Appendix F for detailed information on the method for estimating the cross-price elasticities.

Table 8.5 reflects prices and incomes per capita in US dollars for the year 2016. For each new assessment, the ranges of prices (e.g. gasoline price ≤30 cents) and incomes per capita (e.g. income per capita ≥$24,000) should be adjusted to the year of the assessment. To find the accurate elasticity values in the above tables, follow these three steps:

1. Collect data for actual fuel prices (annual average) and income per capita (annual average) in the local currency for the year of the assessment (most recent year with available data).

TABLE **8.4**

Default gasoline own-price elasticity ($\varepsilon_{gasoline}$) values for approach C (national/city level)

Gasoline price (2016 US cents per litre)	Income per capita (2016 $)		
	≤12,000	12,000–24,000	≥24,000
≤30	–0.15	–0.11	–0.22
30–80	–0.22	–0.24	–0.22
≥80	–0.26	–0.32	–0.33

Source: Values adapted from Dahl (2012).

[50] APTA (2011).

TABLE **8.5**

Default gasoline cross-price elasticities ($\varepsilon_{cross,j}$) for approach C (city level)

Gasoline price (2016 US cents per litre)	Income per capita (2016 $)		
	≤12,000	12,000–24,000	≥24,000
≤30	Bus 0.09	Bus 0.07	Bus 0.14
	Rail 0.15	Rail 0.11	Rail 0.22
30–80	Bus 0.14	Bus 0.15	Bus 0.14
	Rail 0.22	Rail 0.24	Rail 0.22
≥80	Bus 0.16	Bus 0.20	Bus 0.21
	Rail 0.25	Rail 0.31	Rail 0.32

Source: Values were calculated based on data from APTA (2011) and Dahl (2012). The values are based on US cross-price elasticities (APTA 2011), which are weighted with the respective gasoline price and per capita income (Dahl 2012). See Appendix A for further information.

Data requirements:

a. Actual **fuel price** (annual average) in local currency for the assessment year

b. Actual **per capita income** (annual average) in local currency for the assessment year

2. Convert the local fuel price (annual average) and income per capita (annual average) with PPPs. Use the PPP conversion factors (LCU per international $) for the year of the assessment.[51]
Calculation:

a. Fuel price from step 1a ÷ $PPP_{\text{conversion factor for the year of assessment}}$

b. Per capita income from step 1b ÷ $PPP_{\text{conversion factor for the year of assessment}}$

Results:

a. Fuel price (annual average) in US$ for the assessment year, adjusted to PPP

b. Local per capita income (annual average) in US$ for the assessment year, adjusted to PPP

3. Adjust the ranges of fuel price (e.g. gasoline price ≤30 cents) and income per capita (e.g. income per capita ≥$24,000) in the tables above according to the US CPI between the year 2016 and the year of the assessment.[52]
Calculation:

a. ($\text{US CPI}_{\text{for the year of assessment}} \div \text{US CPI}_{2016}$) × fuel price from tables above (e.g. gasoline price ≤30 cents)

b. ($\text{US CPI}_{\text{for the year of assessment}} \div \text{US CPI}_{2016}$) × per capita income from tables above (e.g. income per capita ≥$24,000)

The results of these three steps are new ranges of fuel prices and per capita incomes for the tables. The elasticity values do not change, but they are now valid for the adjusted ranges of prices and incomes. Users can now apply the PPPs of the local fuel price and income per capita to the adjusted price elasticity tables to find the accurate default price elasticities.

Important factors that influence cross-price elasticities of fuels are security of the public transport system and the ease of mode shift (i.e. ease of use of transport modes, density of public transport network and access to stations). The default cross-price elasticity values shown in Table 8.5 do not consider these two factors. Where users determine that bus and rail passenger transport in their country or in a city reflects a special situation,[53] they should use country-specific cross-price elasticity values.

Box 8.4 provides an example illustrating the choice of default own- and cross-price elasticities for approach C.

[51] World Bank (2019a).

[52] World Bank (2019b).

[53] Special situations might include, for example, an extremely expensive or exclusive public transport system, or a particularly dense and easily accessible public transport system.

BOX **8.4**

Example of choosing default own- and cross-price elasticities for approach C

A country decides to apply the default elasticity values, since no national studies are available and there is no capacity to conduct a study. The country has a mean average income of $13,000 per capita and an annual mean fuel price of $0.50 per litre in 2016.

The resulting default **gasoline own-price** elasticity value is –0.24.

The resulting default **gasoline cross-price** elasticities for the respective passenger transport modes are:

- cross-price elasticity with respect to gasoline price, for motor bus: $\varepsilon_{cross,bus}$ = 0.15
- cross-price elasticity with respect to gasoline price, for rail (average): $\varepsilon_{cross,rail}$ = 0.24.

8.2 Calculate GHG impacts

To calculate the GHG impacts of the policy, both the baseline emissions estimate from Chapter 7 and the price elasticity estimate obtained in Section 8.1 are needed. It is a *key recommendation* to calculate the GHG impacts of the policy using appropriate parameter values and equations. The following sections provide methods for calculating impacts using price elasticity values for approaches A, B and C.

Where the results of the assessment will be used to inform GHG accounting and reporting of progress made towards implementation and achievement of NDCs, and meet the reporting requirements of the transparency framework, users should consider aligning the input parameters (e.g. activity data, emission factors, socioeconomic data) used for the calculation of GHG impacts of transport pricing policies with similar parameters used for GHG accounting and reporting under the Paris Agreement. Some parameters used for the projection of GHG impacts of transport pricing policies can also be used as key indicators for projections developed to meet the reporting requirements of the transparency framework.

Guidance for the interpretation of the results and information about uncertainties are provided in Section 8.3.

8.2.1 GHG impact calculation for approach A

The impact of the policy on the fuel demand for transport is reflected by the price elasticity. With an increase in fuel prices, the fuel price elasticity is negative, indicating a decreasing demand for fuel and a subsequent reduction in GHG emissions.

The following input data are needed for the GHG impact calculation using approach A (see Sections 7.2 and 8.1 for methods for calculating these inputs):

- baseline fuel use from gasoline and diesel fuel mix for each year *y* (F_y)
- baseline GHG emissions from gasoline and diesel fuel mix for each year *y* ($BE_{fuel\ mix,y}$)
- fuel mix price elasticity ($\varepsilon_{fuel\ mix}$)
- relative (%) fuel mix price increase (price change due to policy).

Table 8.6 shows the calculation of GHG impacts using approach A. Data in rows A–C are input values taken from Sections 7.2.1 and 8.1, and rows D–G show the output results and the respective equations.

The equations in the column “Data collection/calculation” refer to the respective labelling in the column “Label”. For example, the calculation of the anticipated fuel use (row E) for a specific year multiplies the values of rows C and D (elasticity value in the specific year, relative fuel mix price increase), adds 1 to the result, and then multiplies this by the value of row A (baseline fuel use in the specific year). See Box 8.5 for a full calculation example. The numbers in the box match the examples in Sections 7.2 and 8.1.

TABLE **8.6**

GHG impact calculation using approach A

Label	Parameter	Unit	Data collection/calculation	Example year
A	Baseline fuel use (F_y)	TJ	Input value: from Sections 7.2.1 and 7.4	782,000
B	Baseline emissions ($BE_{fuel\ mix,y}$)	tCO_2	Input value: from Sections 7.2.1 and 7.4	56,069,400
C	Fuel mix own-price elasticity ($\varepsilon_{fuel\ mix}$)	-	Input value: from Section 8.1.2	–0.24
D	Relative fuel mix price increase	%	Input value: according to planned policy	4.5
E	Anticipated fuel use	TJ	= ((C × D) + 1) × A	773,550
F	Anticipated GHG emissions	tCO_2	= ((C × D) + 1) × B	55,463,850
G	Anticipated GHG impact (emissions reductions)	tCO_2	= F – B	–605,650
H	Anticipated relative impact	%	= G ÷ B	–1.1

Abbreviation: -, not applicable

BOX **8.5**

Example of GHG impact calculation for approach A

A government plans to implement a national fuel levy on gasoline and diesel that will target LDVs in the form of a fixed sum per litre – higher for gasoline than for diesel. The fuel levy will increase gasoline prices by 5% and diesel prices by 4%. Gasoline and diesel both have a share of 50% of total fuel use, which means that the **overall fuel price increase amounts to 4.5%.** The ministry has already estimated the baseline scenario and the fuel price elasticities for the example year:

Baseline fuel use: F_y = 782,000 TJ, 50% gasoline and 50% diesel (see row A of Table 8.6)

Baseline emissions: $BE_{fuel\ mix,y}$ = 56,069,400 tCO_2 (see row B)

Elasticity estimate for fuel mix = –0.24 (see row C)

Relative fuel mix price increase = 4.5% (see row D)

The ministry staff now calculate the anticipated fuel use, emissions and GHG impacts according to the equations in Table 8.6:

Anticipated fuel use = ((–0.24 × 4.5%) + 1) × 782,000 TJ = 773,550 TJ (see row E of Table 8.6)

Anticipated GHG emissions = ((–0.24 × 4.5%) + 1) × 56,069,400 tCO_2 = 55,463,850 tCO_2 (see row F)

Anticipated GHG impact = 55,463,850 tCO_2 – 56,069,400 tCO_2 = –605,650 tCO_2 (see row G)

Thus, the GHG reduction in year *y* equals –605,550 tCO_2 or –1.1% compared with the baseline scenario (see row H of Table 8.6).

8.2.2 GHG impact calculation for approach B

The following input data are needed for the GHG impact calculation using approach B (see Sections 7.2 and 8.1):

- baseline fuel use from gasoline and diesel for each year y ($F_{i,y}$)
- baseline GHG emissions from gasoline and diesel for each year y ($BE_{i,y}$)
- gasoline and diesel price elasticities (ε_i)
- relative (%) gasoline and diesel price increases (price change due to policy).

Table 8.7 shows the calculation of GHG impacts using approach B. Data in rows A–F are input values taken from Sections 7.2.2 and 8.1, and rows G–M show the output results and the respective equations.

TABLE **8.7**

GHG impact calculation using approach B

Label	Parameter	Unit	Data collection/calculation	Example year (see Box 8.6)
A	Baseline gasoline use ($F_{gasoline,y}$)	TJ	Input value: from Sections 7.2.2 and 7.4	348,198
B	Baseline diesel use ($F_{diesel,y}$)	TJ	Input value: from Sections 7.2.2 and 7.4	344,000
C	Baseline gasoline emissions ($BE_{gasoline,y}$)	tCO_2	Input value: from Sections 7.2.2 and 7.4	24,130,121
D	Baseline diesel emissions ($BE_{diesel,y}$)	tCO_2	Input value: from Sections 7.2.2 and 7.4	25,490,400
E	Gasoline own-price elasticity ($\varepsilon_{gasoline}$)	-	Input value: from Section 8.1.3	–0.24
F	Relative gasoline price increase	%	Input value: according to planned policy	5
G	Diesel own-price elasticity (ε_{diesel})	-	Input value: from Section 8.1.3	–0.22
H	Relative diesel price increase	%	Input value: according to planned policy	4
I	Anticipated gasoline use	TJ	= ((E x F) + 1) × A	344,020
J	Anticipated diesel use	TJ	= ((G x H) + 1) × B	340,973
K	Anticipated gasoline emissions	tCO_2	= ((E x F) + 1) × C	23,840,560
L	Anticipated diesel emissions	tCO_2	= ((G x H) + 1) × D	25,266,084
M	Anticipated emissions total	tCO_2	= K + L	49,106,644
N	Anticipated total GHG impact (emissions reductions)	tCO_2	= M – (C + D)	–513,877
O	Anticipated relative impact	%	= N ÷ (C + D)	–1.0

Abbreviation: -, not applicable

The equations in the column "Data collection/ calculation" refer to the respective labelling in the column "Label". For example, the calculation of the anticipated gasoline use (row I) for a specific year multiplies the values of rows E and F (elasticity value in the specific year, relative gasoline price increase), adds 1 to the result, and then multiplies this by the value of row A (baseline gasoline use in the specific year). See Box 8.6 for a full calculation example. The numbers match the examples in Sections 7.2 and 8.1.

8.2.3 GHG impact calculation for approach C

Approach C uses cross-price elasticities of a gasoline price increase, and thereby includes mode shifts in the analyses. Own-price elasticities are negative and indicate a decreasing demand for the fuels. In contrast, cross-price elasticities due to the fuel price increase are positive, indicating an increasing demand for alternative transport modes. This means that the number of PKM is reduced for private gasoline cars by the magnitude of the own-price elasticity. The number of PKM in public transport increases by the magnitude of the respective cross-price elasticity. GHG emissions from private gasoline cars decrease, coinciding with the decrease in private gasoline car PKM.

In this methodology and in the example below, it is assumed that the fuel levy on diesel consumption in public transport (bus and rail) is much lower (possibly even non-existent), since it is for private road transport. Most urban bus and rail transport is usually publicly owned. Also, private companies contributing to public transport may be exempt from the levy. Therefore, no own-price elasticity for diesel used in passenger bus and rail transport is included in the analysis.

Note, as mentioned, approach C has different assessment boundaries from approaches A and B, and is therefore not directly comparable with those two approaches.

BOX **8.6**

Example of GHG impact calculation for approach B for an example year

A government plans to implement a national fuel levy on gasoline and diesel that will target vehicles in the form of a fixed sum per litre – higher for gasoline than for diesel. The fuel levy will increase gasoline prices by 5% and diesel prices by 4%. The ministry has already estimated the baseline emissions and the fuel price elasticities for both fuels (gasoline and diesel) in the example year:

- Baseline gasoline fuel use: $F_{gasoline,y}$ = 348,198 TJ (see row A of Table 8.7)
- Baseline diesel fuel use: $F_{diesel,y}$ = 344,000 TJ (see row B)
- Baseline gasoline emissions: $BE_{gasoline,y}$ = 24,130,121 tCO_2 (see row C)
- Baseline diesel emissions: $BE_{diesel,y}$ = 25,490,400 tCO_2 (see row D)
- Elasticity estimate for gasoline = –0.24 (see row E)
- Relative gasoline price increase = 5% (see row F)
- Elasticity estimate for diesel = –0.22 (see row G)
- Relative diesel price increase = 4% (see row H)

The ministry staff now calculate the anticipated fuel use, GHG emissions and GHG impacts according to the equations in Table 8.7:

- Anticipated gasoline fuel use = ((–0.24 × 5%) + 1) × 348,198 TJ = 344,020 TJ (see row I, Table 8.7)
- Anticipated diesel fuel use = ((–0.22 × 4%) + 1) × 344,000 TJ = 340,973 TJ (see row J)
- Anticipated gasoline emissions = ((–0.24 × 5%) + 1) × 24,130,121 tCO_2 = 23,840,560 tCO_2 (see row K)
- Anticipated diesel emissions = ((–0.22 × 4%) + 1) × 25,490,400 tCO_2 = 25,266,084 tCO_2 (see row L)
- Anticipated emissions total = 23,840,560 tCO2 + 25,266,084 tCO_2 = 49,106,644 tCO_2 (see row M)
- Anticipated total GHG impact = 49,106,644 tCO_2 – (24,130,121 tCO_2 + 25,490,400 tCO_2) = –513,877 tCO_2 (see row N)

Thus, the GHG reduction in year y equals –513,877 tCO_2 or –1.0% compared with the baseline scenario (see row O of Table 8.7).

The following **input data** are required for the GHG impact calculation for approach C (see Sections 7.3 and 8.1):

- baseline travel demand in PKM for each transport mode *j* (car, bus, rail) and each year *y* ($PKM_{i,j,y}$)
- own-price elasticities for fuel types diesel and gasoline ($\varepsilon_{gasoline}$, ε_{diesel})
- relative (%) gasoline price increase (price change due to policy)
- cross-price elasticities for transport modes bus and rail ($\varepsilon_{cross,bus}$, $\varepsilon_{cross,rail}$)
- baseline GHG emissions for each fuel type *i* (gasoline, diesel, electricity), transport mode *j* (car, bus, rail) and year *y* ($BEPKM_{i,j,y}$).

Table 8.8 shows the calculation of GHG impacts using approach C. Data in rows A–D, G–I and L–P are input values taken from Chapter 7 and Section 8.1, and rows E–F, J–K and Q–T show the output results and the respective equations. The overall results are calculated in rows U–Z.

TABLE **8.8**

GHG impact calculation using approach C

Label	Parameter	Unit	Data collection/ calculation	Example year	Year *y* (projected)
Passenger car (gasoline)					
A	Baseline PKM with car ($PKM_{car,gasoline,y}$)	PKM	Input value: from Sections 7.3 and 7.4	21,800,000,000	...
B	Gasoline own-price elasticity ($\varepsilon_{gasoline}$)	-	Input value: from Section 8.2.3	–0.24	...
C	Relative gasoline price increase	%	Input value: according to planned policy	5	...
D	Baseline car gasoline emissions per PKM ($BEPKM_{car,gasoline,y}$)	gCO_2/ PKM	Input value: from Sections 7.3 and 7.4	111	...
E	Anticipated PKM with cars	PKM	= ((B × C) + 1) × A	21,538,400,000	...
F	Anticipated gasoline emissions (car)	tCO_2	= D × E ÷ 10^6	2,390,762	...
Passenger bus (diesel)					
G	Baseline PKM with bus ($PKM_{bus,diesel,y}$)	PKM	Input value: from Sections 7.3 and 7.4	15,700,000,000	...
H	Bus cross-price elasticity ($\varepsilon_{cross,bus}$)	-	Input value: from Sections 8.2.3	0.15	...
I	Baseline bus diesel emissions per PKM ($BEPKM_{bus,diesel,y}$)	gCO_2/ PKM	Input value: from Sections 7.3 and 7.4	83	...
J	Anticipated PKM with bus	PKM	= ((H × C) + 1) × G	15,817,750,000	...
K	Anticipated diesel emissions (bus)	tCO_2	= I × J ÷ 10^6	1,312,873	...

TABLE **8.8**, continued

GHG impact calculation using Approach C

Label	Parameter	Unit	Data collection/ calculation	Example year	Year *y* (projected)
Passenger rail (diesel and electricity)					
L	Baseline PKM with diesel rail ($PKM_{rail,diesel,y}$)	PKM	Input value: from Sections 7.3 and 7.4	12,400,000,000	...
M	Baseline PKM with electric rail ($PKM_{rail,electricity,y}$)	PKM	Input value: from Sections 7.3 and 7.4	5,600,000,000	...
N	Rail cross-price elasticity ($\varepsilon_{cross,rail}$)	-	Input value: from Section 8.2.3	0.24	...
O	Baseline rail diesel emissions per PKM ($BEPKM_{rail,diesel,y}$)	gCO_2/ PKM	Input value: from Sections 7.3 and 7.4	64	...
P	Baseline rail electricity emissions per PKM ($BEPKM_{rail,electricity,y}$)	gCO_2/ PKM	Input value: from Sections 7.3 and 7.4	63	...
Q	Anticipated PKM with diesel rail	PKM	= ((N × C) + 1) × L	12,548,800,000	...
R	Anticipated PKM with electric rail	PKM	= ((N × C) + 1) × M	5,667,200,000	...
S	Anticipated diesel emissions (rail)	tCO_2	$= O \times Q \div 10^6$	803,123	...
T	Anticipated electricity emissions (rail)	tCO_2	$= P \times R \div 10^6$	357,034	...
Overall results					
U	Reference emissions total	tCO_2	$= ((A \times D) + (G \times I) + (L \times O) + (M \times P)) \div 10^6$	4,869,300	...
V	Anticipated emissions total	tCO_2	= F + K + S + T	4,863,792	...
W	Anticipated total GHG impact (emissions reduction)	tCO_2	= V – U	–5,508	...
X	Anticipated relative impact	%	= W ÷ U	–0.1	...
Y	Increased capacity requirement of bus system	%	= ((Q + R) ÷ (L + M)) – 1	+1.2	...
Z	Increased capacity requirement of rail system	%	= J ÷ G – 1	+0.8	...

Abbreviation: -, not applicable

The equations in the column "Data collection/ calculation" refer to the respective labelling in the column "Label". For example, the calculation of the anticipated PKM by car with gasoline use (row E) for a specific year multiplies the values of rows C and D (elasticity value in the specific year, relative gasoline price increase), adds 1 to the result, and then multiplies this by the value of row A (baseline PKM with car in the specific year). See Box 8.7 for a full calculation example. The numbers match the examples in Sections 7.3 and 8.1.

8.3 Interpret the results

The calculations in this methodology are subject to large uncertainties. It is a *key recommendation* to carefully interpret the results, including assessing uncertainty and the GHG impacts of use of revenues from the policy. Users should interpret the results of the calculations following these steps:

1. Check conditions of applicability for the assessments. Applicability is limited when
    - a country has special circumstances (e.g. very low or high fuel prices or income per capita)
    - the fuel price increase is very high or very low
    - fuel is a luxury good that is only accessible to a small, wealthy part of the population
    - there are other political or legal processes or conditions interfering with the policy.
2. Be transparent about high uncertainties in the following data-collection and calculation processes
    - activity data estimation
    - baseline activity data estimation
    - emission factors and other conversion factors
    - projection of baseline scenarios
    - price elasticity value estimation.
3. Indicate a range of the results rather than single values to account for the uncertainty (e.g. a range from 50% to 100% of the single result value).
4. Undertake a plausibility check of the results
    - Consult further literature and data sources (see Appendix B).
    - Compare results with similar assessments from other countries or cities (i.e. conduct a benchmarking exercise).
    - Conduct a stakeholder consultation process.
5. Undertake a top-down and bottom-up consistency check when applying approaches B or C
    - Compare $F_{gasoline,car,y}$ with total gasoline fuel used for private passenger road transport from the national energy balance or similar national energy statistics.
    - Be transparent when reporting differences in results from bottom-up and top-down estimations.
6. Qualitatively assess and discuss use of revenues from the fuel tax or levy
    - If the revenues are invested in activities that tend to increase emissions – such as general government spending, or building or extension of roadways – the net emissions reductions from the policy may be considerably reduced or the policy may lead to higher overall emissions.
    - If the revenues are invested in activities that tend to decrease emissions – such as investments in public transport or schemes to promote low-emission vehicles – the emissions reductions may be increased as a result of easier and more convenient mode shift.
7. Conduct the ex-post assessment presented in Chapter 9.

Studies on fuel price elasticities yield very broad and diverse results (see Appendix B for an overview). Therefore, the default values presented in this methodology have very high uncertainties, estimated by the authors of this methodology to be between 50% and 100%; they may be higher for specific cases.

Elasticities depend on the transport alternatives that are available and thus on the specific situation in the country. Care should be taken to implement the appropriate increase in fuel price based on an estimate of elasticity, to avoid adverse effects, such as decreased mobility for the poorest populations. The assumptions made to choose elasticity values are important, given that these values do not remain the same under continuous price increases.

BOX **8.7**

Example of GHG impact calculation for approach C

A government plans to implement a national fuel levy on gasoline that will target vehicles in the form of a fixed sum per litre. The fuel levy will increase gasoline prices by 5%. It is decided that public transport is not subject to the levy (i.e. diesel used in passenger bus and rail transport).

The ministry staff start by analysing private road passenger transport. They retrieve the following data from the baseline emissions estimates they conducted before (see Section 7.3) and from the choice of price elasticities (see Section 8.1):

$PKM_{gasoline,car,y}$ = 21,800 million PKM (see row A of Table 8.8)

$\varepsilon_{gasoline}$ = –0.24 (see row B)

Relative gasoline price increase = 5% (see row C)

$BEPKM_{gasoline,car,y}$ = 111 gCO_2/PKM (see row D)

With these data, they calculate PKM and emissions from private passenger cars:

Anticipated PKM with cars = ((–0.24 x 5%) + 1) × 21,800,000,000 PKM = 21,538,400,000 PKM (see row E)

Anticipated gasoline emissions (car) = 111 gCO_2/PKM × 21,538,400,000 PKM ÷ 10^6 = 2,390,762 tCO_2 (see row F)

In a second step, the ministry staff analyse passenger bus transport. The following data inputs are given from their earlier analyses (no diesel own-price elasticity is required, since public transport is not subject to the levy):

$PKM_{diesel,bus,y}$ = 15,700 million PKM (see row G)

$\varepsilon_{cross,bus}$ = 0.15 (see row H)

$BEPKM_{diesel,bus,y}$ = 83 gCO_2/PKM (see row I)

With these data, they calculate PKM and emissions from passenger buses:

Anticipated PKM with bus = ((5% × 0.15) + 1) × 15,700,000,000 PKM = 15,817,750,000 PKM (see row J)

Anticipated diesel emissions (bus) = 15,817,750,000 PKM × 83 gCO_2/PKM / 1,000,000 = 1,312,873 tCO_2 (see row K)

In a third step, the ministry staff analyse passenger rail transport with diesel and electricity. The following data inputs are given from their earlier analyses (no diesel own-price elasticity is required, since public transport is not subject to the levy):

$PKM_{diesel,rail,\ y}$ = 12,400 million PKM (see row L)

$PKM_{electricity,rail,\ y}$ = 5,600 million PKM (see row M)

$\varepsilon_{cross,rail}$ = 0.24 (see row N)

$BEPKM_{diesel,rail,y}$ = 64 gCO_2/PKM (see row O)

$BEPKM_{electricity,rail,y}$ = 63 gCO_2/PKM (see row P)

With these data, they calculate PKM and emissions from diesel and electric rail:

Anticipated PKM with diesel rail = ((5% × 0.24) + 1) × 12,400,000,000 PKM = 12,548,800,000 PKM (see row Q)

Anticipated PKM with electric rail = ((5% × 0.24) + 1) × 5,600,000,000 PKM = 5,667,200,000 PKM (see row R)

Anticipated diesel emissions (rail) = 12,548,800,000 PKM × 64 gCO_2/PKM / 1,000,000 = 803,123 tCO_2 (see row S)

Anticipated electricity emissions (rail) = 5,667,200,000 PKM × 63 gCO_2/PKM / 1,000,000 = 357,034 tCO_2 (see row T)

Finally, the ministry staff can calculate the overall GHG impacts:

Reference emissions total = ((21,800 million PKM × 111 gCO_2/PKM) + (15,700 million PKM × 83 gCO_2/PKM) + 12,400 million PKM × 64 gCO_2/PKM) + (5,600 million PKM × 63 gCO_2/PKM)) = 4,869,300 tCO_2 (see row U)

Anticipated emissions total = 2,390,762 tCO_2 + 1,312,873 tCO_2 + 803,123 tCO_2 + 357,034 tCO_2 = 4,863,792 tCO_2 (see row V)

Anticipated total GHG impact = 4,863,792 tCO2 – 4,869,300 tCO2 = –5,508 tCO_2 (see row W)

Anticipated relative impact = –5,508 tCO_2 / 4,869,300 tCO_2 = –0.1% (see row X)

Thus, the GHG reduction in year *y* equals 5,395 tCO_2 or 0.1% compared with the baseline scenario (see row W of Table 8.8).

Note: Users can estimate the extent of mode shifts towards public transport:

Increased capacity requirement of bus system = 1.2% (see row Y)

Increased capacity requirement of rail system = 0.8% (see row Z)

9 Estimating GHG impacts ex-post

Ex-post impact assessment is a backward-looking assessment of the GHG impacts achieved by a policy to date. The GHG impacts can be assessed during the policy implementation period or in the years after implementation. In contrast to ex-ante assessment, which is based on forecasted values, ex-post assessment involves monitored data collected during the policy implementation period. An ex-post assessment is important to check the plausibility of the estimated emissions reductions from the ex-ante estimation. Users who are estimating ex-ante GHG impacts only can skip this chapter.

Checklist of key recommendations

- Estimate or update baseline emissions using observed values for parameters that are not affected by the policy and estimated values for parameters that are affected by the policy
- Estimate the GHG impacts of the policy over the assessment period, for each GHG source included in the GHG assessment boundary

9.1 Estimate or update baseline emissions (if relevant)

It is a *key recommendation* to estimate or update baseline emissions using observed values for parameters that are not affected by the policy and estimated values for parameters that are affected by the policy. The baseline scenario can be estimated following the method in Chapter 7. Further guidance on monitoring parameters is provided in Chapter 11.

Where the baseline scenario was determined and baseline emissions were estimated in a previous ex-ante impact assessment, this should be updated by replacing estimated values with observed data.

9.2 Estimate GHG impacts

The performance of the policy should be evaluated to ascertain whether it has been implemented as envisaged and to estimate its actual GHG impacts. It is a *key recommendation* to estimate the GHG impacts of the policy over the assessment period, for each GHG source included in the GHG assessment boundary.

To estimate the GHG impacts for a policy that has not been assessed ex-ante, follow the steps for ex-ante impact assessment (see Chapter 8). If an ex-ante impact assessment was done previously, that impact assessment should be updated using observed values.

FIGURE **9.1**

Overview of steps in the chapter

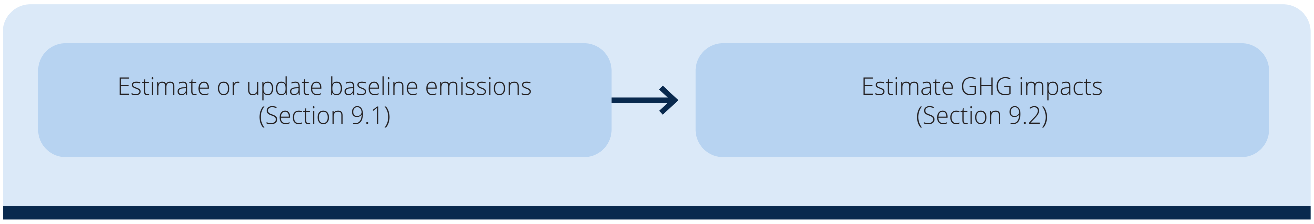


Table 9.1 provides the key indicators and parameters that may need to be monitored or updated when conducting an ex-post assessment. With these updated indicator and parameter values, a more accurate estimation for the GHG impacts of the policy is calculated, using the methods in Chapters 7 and 8.

If an ex-ante impact assessment was not done previously, follow the methods in Chapters 7 and 8 using current values for all relevant monitored indicators and parameters.

Box 9.1 provides a case study of an ex-post assessment of a policy involving reduction of subsidies for fossil fuels in Indonesia.

TABLE **9.1**

Indicators and parameters to consider when undertaking or updating the assessment of the policy

Indicator/ parameter	Description	Potential data sources	Related section in ex-ante assessment
Coverage of policies	The policy that is actually implemented may differ from the design of the policy at the time of the ex-ante assessment. Therefore, the type of fuels (or consumers) covered by the policy may change (e.g. exemptions for certain consumer groups may be implemented that change the impact).	Law or regulation for implementation of the policy	Changes in coverage of policy impact system boundaries for GHG sources considered in Chapter 7
Level of pricing	During the process of designing the policy, the level of the pricing or the implementation time and speed may change.	Law or regulation for implementation of the policy	Used for updating pricing signal in Section 8.2
Approach	Better data on fuel consumption (or price elasticities) may be available that allow users to use a higher-level approach (i.e. B or C) or provide a better basis for determining fuel price elasticities.	National data sources	Used for updating choice in Section 4.2.2, and calculations in Chapter 7 and Section 8.1
Baseline data	More recent data may be available on fuel consumption, for determining baseline emissions (e.g. for the last year before the implementation of the policy), or on transport emissions projections. In general, only activity data from before the policy was implemented can be used to update the baseline, because, after that point, the impact of the policy has already led to a deviation of emissions from the baseline scenario.	See all parameters in Chapter 7	Used for updating calculations in Chapter 7

BOX **9.1**

Ex-post assessment of subsidy removal in Indonesia

In 2014, the Government of Indonesia reduced subsidies on fossil fuels. For gasoline, this led to a price increase of around 25%. There were multiple reasons for this pricing policy – the main reasons were government budget limitations, high international fuel prices (combined with limited fuel production capacities in Indonesia and thus higher dependency on imports) and the realization that the subsidies were not suitable to resolving the poverty problem in Indonesia.

The subsidy removal in Indonesia was assessed ex-post using approach B of the ICAT *Transport Pricing Methodology*. A local team from the Trisakti School of Transportation Management,[54] based in Jakarta, conducted the assessment, as follows:

- country – Indonesia
- base year – 2013; assessment year – 2016
- fuels – gasoline (RON 88) and diesel: ex-post data from the Indonesian Ministry of Environment and Forestry
- price elasticities – default values from the *Transport Pricing Methodology*
- emission factors – country-specific data from the Ministry of Environment and Forestry.

The assessment showed that the subsidy removal on RON 88 gasoline and thereby the increase in the price led to a decrease in RON 88 consumption of around 6%. The case is different for diesel, where the price increase was less significant; after correcting for inflation in the assessment year, the impact of the pricing policy on diesel consumption was negligible.

The local team considered the *Transport Pricing Methodology* very helpful for conducting the pricing policy assessment, and for understanding changes in fuel prices and impacts of these changes on fuel demand. In particular, the step-by-step guidance and illustrative examples helped them when they encountered problems or questions throughout the process. The report of the Trisakti School of Transportation Management, with detailed information about the assessments conducted in Indonesia, will be published on the ICAT website.[55]

[54] Institut Transportasi & Logistik (ITL) Trisakti, https://itltrisakti.ac.id.

[55] Sinaga et al. (forthcoming).

10 Estimating GHG impacts for vehicle purchase incentives and road pricing

This chapter provides supplementary methods for estimating GHG impacts of vehicle purchase incentives and road pricing policies. Previous chapters of the methodology have focused on helping users estimate the impacts of higher fuel prices, using price elasticities of demand. This chapter provides a condensed approach to help users estimate the impacts of purchase incentives for highly efficient vehicles and road pricing policies.

10.1 Overview of vehicle purchase incentives and road pricing

Many of the considerations for quantifying the impacts of fuel price increases (see Chapters 7, 8 and 9) also apply to other pricing policies. However, there are two key differences:

- Fuel price increases generally affect the entire vehicle fleet, or at least the entire gasoline- or diesel-fuelled subfleet. In contrast, road pricing policies often affect only a particular geographic region, a particular time of day or a particular market segment, such as employee commutes to work.
- Fuel price increases reduce GHG emissions through two major channels: reducing vehicle travel and improving fuel economy. Most other pricing policies reduce emissions through only one channel. For example, road pricing only reduces vehicle travel, and usually does not encourage a switch to the use of more efficient vehicles. Incentives for highly efficient vehicles improve fuel economy or encourage a switch to lower-carbon fuels, but do not reduce vehicle travel.

If several policies or measures are implemented simultaneously[56] as a mutually reinforcing package, the policies and measures can be assessed together as a package of policies. An example of such a package is a levy on fossil fuels used in fossil-fuelled vehicles to discourage their use, purchase incentives for low-GHG-emission vehicles (such as electric vehicles) to encourage their market uptake, and road pricing and efficient parking pricing that discourage the use of fossil-fuelled vehicles and encourage the use of low-GHG-emission vehicles. The assessment of the package needs to take into account the timing and the specific type of measures (see Section 5.2 and Chapter 5 of the *Policy and Action Standard*). Note that, when assessing a package of policies, there may be overlaps or interactions between the policies being assessed.

10.2 Purchase incentives for low-GHG vehicles

10.2.1 Overview of purchase incentives

Governments can increase the fuel efficiency of the vehicle fleet and/or promote a shift to lower-carbon fuels by providing incentives for the purchase of selected vehicles. This policy is most applicable to electric, plug-in hybrid-electric, hydrogen-fuelled and other vehicles that are not powered by gasoline or diesel. However, it can also be applied to highly efficient gasoline or diesel vehicles, such as hybrid-electric vehicles, where the technology is embryonic or commands a low market share.

Governments can provide a range of purchase incentives, including the following:

- **Lower purchase taxes** – reduce the cost of purchasing a low-GHG vehicle by providing tax incentives at the point of sale. For example, Hong Kong waives the First Registration Tax for electric private cars up to a maximum of HK$ 97,5000 (~US$ 25,000). Commercial electric vehicles and electric motorcycles in Hong Kong are also eligible for tax concessions.[57] India and Malaysia also reduce

[56] If the policies or measures are not implemented simultaneously (i.e. one measure has already been implemented in the past), the impact of the already implemented measure is reflected in the baseline, and the impacts of the policies and measures cannot be combined.

[57] Hong Kong Environmental Protection Department (2019).

excise duties for some hybrid-electric and battery-electric vehicles.

- **Purchase rebates** – reduce the cost of purchasing a low-GHG vehicle through rebates or similar purchase incentives. These programmes work in a similar way to lower purchase taxes, but the rebate is claimed at a later date rather than applied at the point of sale. For example, Sweden's SEK 40,000 (~US$ 4,400) rebate for new cars that achieve a threshold level of emissions was introduced in 2012.[58]

- **Income tax credits** – reduce the cost of purchasing a low-GHG vehicle or equipment such as home chargers, by providing incentives that can be claimed at a later date via an income tax credit. For example, in the United States, an income tax credit of up to $7,500 was offered for the purchase of certain electric vehicles.

- **Lower vehicle taxes** – reduce the annual costs of owning a low-GHG vehicle by lowering or eliminating annual registration fees or vehicle taxes. For example, China exempts electric vehicles from annual registration taxes.[59]

10.2.2 Success factors for purchase incentives

The design of purchase incentives has a significant impact on their effectiveness in increasing the market share of low-GHG vehicles, and in reducing emissions. Table 10.1 summarizes some of the success factors.

TABLE **10.1**

Factors that increase the effectiveness of purchase incentives for low-GHG vehicles

Factor	Description
Incentive structure	The closer the incentive to the point of sale, the greater the impact on purchase decisions. For example, sales tax exemptions have a greater impact than income tax exemptions that must be applied for at a later date.
Programme durability	Longer-term, predictable incentive programmes can give manufacturers the certainty to invest and bring more low-GHG vehicles to market, and provide better marketing for consumers.
Individual eligibility	Incentives that are limited to lower-cost vehicles or targeted to lower-income consumers can reduce the total impact of an incentive programme (measured in tCO_2e reduced), but improve its cost-effectiveness (cost per tonne reduced).
Technology eligibility	Focusing on new technologies with minimal market share, such as battery-electric vehicles, is likely to improve the cost-effectiveness of an incentive programme. Allowing mature technologies such as hybrid-electric vehicles to qualify means that incentives will go to many people who would have purchased that low-GHG vehicle anyway.[60]
Scrappage	Programme effectiveness can be improved by requiring scrappage of a high-emission vehicle to qualify for the incentive, or by providing a larger incentive.
Impact on high-emission vehicles	The most effective programmes not only provide incentives to purchase low-GHG vehicles but impose fees or other disincentives on high-GHG vehicles. Such programmes can be structured in the form of a revenue-neutral "feebate" (a combination of fee and rebate).[61]

[58] Transport Styrelsen (no date).

[59] Yang et al. (2016).

[60] For example, DeShazo, Sheldon and Carson (2016).

[61] For a discussion of feebates, see German and Meszler (2010).

10.2.3 Impacts of purchase incentives

Figure 10.1 provides an example causal chain for purchase incentives for low-GHG vehicles. The most direct impact of purchase incentives on GHG emissions is an increase in the market share of electric, hybrid and other efficient vehicles, which reduces emissions per kilometre travelled either through greater fuel efficiency or through a shift to lower-carbon fuels. In the longer term, an even greater impact on emissions may occur through technological improvements, as vehicle manufacturers gain experience with new fuels and exploit economies of scale.

Purchase incentives can increase emissions in two ways. First, low-GHG vehicles are likely to be cheaper to drive because they are more fuel-efficient, and/or because fuels such as CNG or electricity cost less per unit of energy, particularly if these fuels are tax exempt or taxed at a lower rate. The lower cost per kilometre driven may increase vehicle travel – a rebound effect. Second, if low-GHG vehicles are cheaper to purchase, overall car ownership may increase.

In the causal chain, increased emissions due to the rebound effect (higher levels of car ownership) and the impact of reduced GHG emissions from vehicle travel due to long-term improvements in technology may be considered to cancel each other out, and thus would not be included in the GHG assessment boundary.

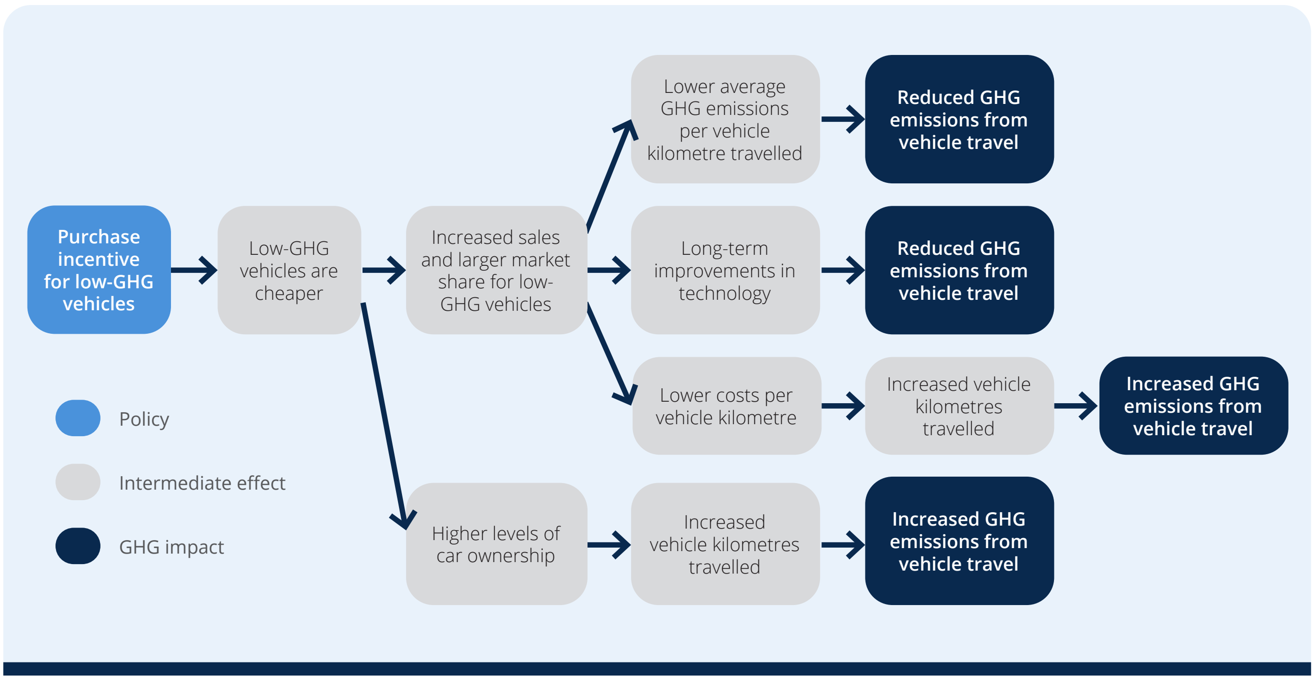
The track record of purchase incentives in expanding the market share of low-GHG vehicles is mixed. Some studies find no effect, while other studies find a measurable impact on GHG emissions. When expressed in terms of the cost per tCO_2e reduced, $100–300 is a typical range.[62] The impact of purchase incentives depends on several factors, summarized in Table 10.1. A general rule, however, is that purchase incentives and other policies that target the fixed costs of vehicle ownership tend to have a smaller impact than policies that target the variable costs of vehicle operation, such as fuel taxes.

10.2.4 Simplified approach for calculating GHG impacts of purchase incentives

Given the range of programme design and other factors that affect the GHG impact of purchase incentives, this methodology recommends a simplified approach to calculating the impact. The simplified approach is based on the aggregate

FIGURE **10.1**

Example causal chain for purchase incentives for low-GHG vehicles



[62] Li et al. (2013); Huse and Lucinda (2014).

relationship between electric vehicle (battery-electric and plug-in hybrid-electric) market share, and the cost premium (net of incentives) for electric vehicles. Such a simple approach does not account for all the impacts shown in the causal chain. The assumption is that the non-quantified impacts cancel each other out, or are within the overall range of uncertainty.

Note that this simplified method does not account for the many other factors that affect electric vehicle market share. As well, the relationship between cost and market share is likely to change as electric vehicle technology matures. Further uncertainty is introduced when applying the method to other technologies, such as hydrogen or CNG. Caution and professional judgment are needed in these circumstances.

Follow the steps below to calculate the GHG impacts of purchase incentives using the simplified approach.

Step 1: Calculate the average value of the rebate as a percentage of the vehicle retail price

- Use equation 10.1.

  Equation 10.1: Estimate average value of the rebate

$$\textit{Average}\text{ value of the rebate (percentage)} = \frac{\text{Average rebate}}{\text{Average vehicle retail price}}$$

- For flat-rate rebates and similar incentives, the sales-weighted average retail price of eligible vehicle models should first be calculated. For example, if the sales-weighted average price of low-GHG vehicles is $50,000, a $2,100 rebate is equal to 4.2%.

  For reductions in ad valorem sales taxes[63] or excise duties, this step is straightforward. The example calculation below shows how to calculate the impact of a reduction in tax from 20% to 15%, which results in a rebate of 4.2%. In this equation, 1.2 refers to a normalized vehicle retail price (i.e. 100% + 20%).

  Example calculation: (0.2 × $50,000 – 0.15 × $50,000) / (1.2 × $50,000) × 100 = 4.2%

[63] Taxes according to the value of the vehicle.

Step 2: Estimate the change in market share of low-GHG vehicles

- Use equation 10.2.

  Equation 10.2: Estimate change in market share of low-GHG vehicles

$$\text{Market share (percentage point change)} = \text{beta} \times \text{average rebate value [from step 1]} \times \text{market share (percentage point before rebate)}$$

  A default value for elasticity beta of 0.3 may be assumed if no country-specific data are available (derived from aggregate market data and the judgment of the methodology development leads).

  For example, a rebate worth 4.2 percentage points is estimated to translate into a 0.3 × 4.2 = 1.26 percentage point increase in low-GHG market share (e.g. from 0.50% to 0.5 × 1.0126 = 0.5063% of the market).

Step 3: Estimate the per-kilometre emissions reductions from low-GHG vehicles

- Emission factors (CO_2e/km) for both eligible low-GHG vehicles and the existing vehicle fleet can be calculated as discussed in Chapter 7 for baseline emissions. The difference between the baseline scenario and the policy scenario represents the per-kilometre emissions savings from low-GHG vehicles.

Step 4: Calculate GHG impacts

- Use equation 10.3.

  Equation 10.3: Calculate GHG impacts

$$\text{GHG impact per year} = \text{market share (percentage point change)} \times \text{annual new vehicle sales} \times \text{per-kilometre emissions reductions} \times \text{average annual km per vehicle}$$

For this equation:

- market share is calculated in step 2

- annual new vehicle sales is obtained from official national statistics, and is consistent with the market definition in step 2. For example, if step 2 refers to the low-GHG share of the passenger car market (i.e. excluding commercial vehicles), annual new vehicle sales should refer to passenger cars only

- per-kilometre emission reductions are calculated in step 3
- average annual km per vehicle is estimated using national statistics on annual vehicle kilometres and vehicle lifespan. If this information is not available, a default value of 15,000 km per year can be used.[64]

Where a purchase incentive (rebate) for low-GHG vehicles is combined with a (higher) tax for fossil-fuelled vehicles introduced at the same time, both vehicle price changes should be taken into account. A simplified method to calculate the combined GHG impacts of these two pricing measures is to translate the price increase of the fossil-fuelled vehicle into the overall rebate for the low-GHG vehicle (i.e. considering both the price increase for fossil-fuelled vehicles and the price reduction for low-GHG vehicles) and to use the same methodology as described above. Below is an example (adapted from step 1 above):

- The low-GHG vehicle originally costs $50,000, and a rebate of $2,100 is granted (average rebate value = 4.2%).
- The fossil-fuelled vehicle originally costs $25,000, and a vehicle tax of 2% on the vehicle price is introduced at the same time (absolute price increase is 0.02 × $25,000 = $500).
- The increased price of the fossil-fuelled vehicle is translated into the rebate (the total "combined rebate" equals $2,100 + $500 = $2,600).
- The combined rebate value for the low-GHG vehicle equals $2,600 / $50,000 = 5.2%.

This combined rebate value can be used to calculate the change in market share (step 2 above), and the following steps can then be used to calculate the GHG impacts of both pricing policies. Where one measure has been implemented earlier than the other measure, the impacts cannot be combined. For example, if the fossil-fuelled vehicle tax was implemented in 2010 and a rebate for electric vehicles was implemented in 2015, the activity data used to determine the baseline for the assessment of the rebate in 2015 already include the impact of the fossil-fuelled vehicle tax introduced earlier.

[64] Schlömer et al. (2014).

10.2.5 Advanced approach for calculating GHG impacts of purchase incentives

Where more data on vehicle prices, technologies and consumer demand are available, and econometric expertise is also available, more advanced approaches can be used to estimate the GHG impacts of purchase incentives. These advanced approaches will capture local market dynamics in a more sophisticated way than the simplified approach presented in Section 10.2.4, and can also be applied to a wider range of vehicle technologies. The focus of the references listed below is on simulation models and other approaches that can predict the impact on incentive programmes, rather than ex-post analyses:

- International Council on Clean Transportation (2014). Feebate Simulation Tool[65]
- DeShazo, J.R., Tamara L. Sheldon and Richard T. Carson (2016). Designing policy incentives for cleaner technologies: lessons from california's plug-in electric vehicle rebate program[66]
- Jin, Lingzhi, Stephanie Searle and Nic Lutsey (2014). *Evaluation of State-Level U.S. Electric Vehicle Incentives*[67]
- Haultfoeuille, Xavier, Isis Durrmeyer and Philippe Février (2016). Distangling sources of vehicle emissions reduction in France: 2003–2008.[68]

Box 10.1 provides a case study from Indonesia.

[65] Available at: www.theicct.org/feebate-simulation-tool.

[66] Available at: www.sciencedirect.com/science/article/abs/pii/S0095069617300049.

[67] Available at: www.theicct.org/evaluation-state-level-us-electric-vehicle-incentives.

[68] Available at: www.tse-fr.eu/articles/disentangling-sources-vehicle-emissions-reduction-france-2003-2008.

BOX **10.1**

Low-cost green cars and electric vehicles in Indonesia

A local team from the Trisakti School of Transport Management[69] assessed two types of purchase incentive policies (as well as conducting an ex-post assessment for removal of subsidies on fossil fuels – see Section 9.2). The assessments show that the methods in the ICAT *Transport Pricing Methodology* can be extended to specific needs that a country or practitioner may have. The report of the Trisakti School of Transportation Management, with detailed information about the assessments conducted in Indonesia, will be published on the ICAT website.[70]

Low-cost green cars: In 2013, the Indonesian Government introduced the "Low-Cost Green Car" (LCGC) programme. The policy is based on tax cuts for more-efficient cars, which increased sales from 45,000 units in 2013 to 850,000 in 2017. The policy was assessed using an ex-post approach based on Section 10.2 of this methodology, as follows:

- country – Indonesia
- base year – 2013; assessment year – 2017
- fuels – gasoline (RON 88, 92, 95, 98, 100): ex-post data from the Indonesian Ministry of Environment and Forestry
- price elasticity – default value
- emission factors – country-specific data from the Ministry of Environment and Forestry, and car manufacturers.

Other than as explained in Section 10.2, the assessment accounts for the fact that, with the cheaper LCGC on the market, it became affordable for more people to own a car. This is presumed to have led to 20% higher car sales compared with the baseline. As a result, emissions are assumed to have been higher with the LCGC programme than they would have been in the baseline (subject to high uncertainties).

Electric vehicles: In August 2019, the Indonesian Government announced that it would accelerate the electric vehicle programme. Production of new cars is aimed to fully shift from conventional to electric by 2040. Since this policy was new at the time of the assessment, little information and data were available. The policy was assessed using an extended ex-ante approach, as follows:

- country – Indonesia
- base year – 2020; assessment year – 2035
- fuels – gasoline (RON 92); electricity
- price elasticity – default value
- emission factors – country-specific data from the Ministry of Environment and Forestry, and average electricity grid emission factor for the different grids operated in Indonesia.

Because of high uncertainties, particularly in the projected electricity grid mix (i.e. coal versus renewables), different scenarios were used to compute the impacts of the policy.

10.3 Road pricing

10.3.1 Overview of road pricing

National and local governments can reduce vehicle travel by charging distance-based fees to use particular roads, or charging fees for access to city centres. Road pricing policies can be implemented in several different ways:

- **Cordon pricing.** Drivers must pay to enter the tolled area, typically a city centre or regional core. Singapore, London, Rome and Stockholm are some of the most notable examples.
- **Toll roads.** Drivers must pay for access to a particular link in the roadway network, often a bridge or tunnel. Toll roads are the most common implementation of road pricing.
- **Distance-based charges.** Vehicles are equipped with a GPS-based recording device,

[69] Institut Transportasi & Logistik (ITL) Trisakti, https://itltrisakti.ac.id.

[70] Sinaga et al. (forthcoming).

and drivers are charged per kilometre driven. Switzerland, for example, charges fees to heavy vehicles based on weight, emissions levels and the distance driven. Annual odometer audits can also be used. Many European countries have implemented distance-based charges for heavy goods vehicles.

10.3.2 Impacts of road pricing

Figure 10.2 shows an example causal chain for road pricing policies. The primary impact of the increase in driving costs per kilometre travelled is reduced vehicle travel within the cordon or on the priced facility, which results in reduced emissions. The reduction in vehicle travel occurs through two main channels: a reduction in overall trip-making, and a modal shift to walking, bicycling, public transport and carpooling. The degree of modal shift will depend on the quality of these substitutes – for example, cities such as London with high-quality buses and trains will experience a greater shift towards public transport.

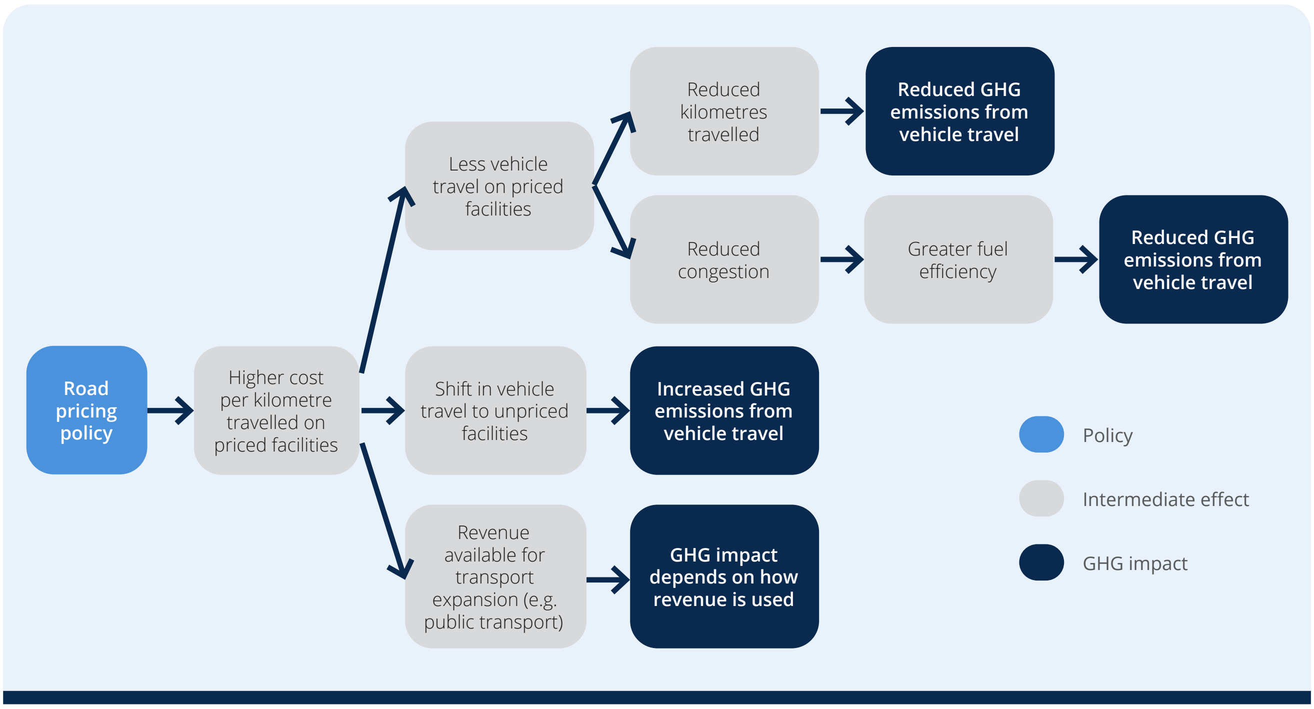
A secondary emissions reduction impact can occur if reductions in congestion allow vehicles to operate more efficiently, through reductions in vehicle idling or operation at inefficiently low speeds.

The reduction in emissions is likely to be partially offset by a shift in vehicle travel to non-priced facilities. For cordon pricing, the smaller the cordon, the greater this substitution effect is likely to be. For toll roads, the extent of the substitution will depend on the availability of alternative, parallel routes.

Other emissions impacts depend on how pricing revenue is used. Cities such as London primarily use the revenue to expand public transport and non-motorized transport facilities; this is likely to reinforce emissions reductions, given that public transport emissions are likely to be relatively small. Many road tolling policies, in contrast, use the revenue to expand roadway capacity, which is likely to increase emissions. In these cases, emissions from the additional travel induced by road congestion are likely to offset the emissions savings from road pricing. Estimating the additional vehicle travel and emissions is beyond the scope of this methodology. As well, this methodology does not apply to policies that provide fee-based access to dedicated “express lanes” or a similar less congested facility, while leaving other lanes free of charge.

FIGURE **10.2**

Example causal chain for road pricing policies



10.3.3 Simplified approach for calculating GHG impacts of road pricing policies

The impact of cordon pricing can be estimated based on the experience of similar cities. The impact of toll roads and distance-based charges can be quantified more precisely using price elasticities of demand. Follow the steps below for a simplified approach to calculating the GHG impacts of road pricing policies.

Cordon pricing

Step 1: Estimate vehicle travel within the cordon, by vehicles that would be subject to the charge (vehicle km/year). Travel by exempt vehicles (e.g. taxis) should be excluded, as should travel outside the hours of operation.

Step 2: Estimate the change in vehicle travel, by applying a percentage reduction to the vehicle travel estimated in step 1. A default reduction of 20% is recommended, based on the experiences of cities that have implemented cordon pricing, where reductions range from 10% to 44%.[71] This assumes that the price is in a similar range to previously implemented programmes in cities such as London (~$14 per day), Stockholm (up to ~$4 per day per entry or exit), and Singapore (up to ~$4.25 per entry or exit). However, project-specific estimates may be available from a travel demand model or similar source.

Step 3: Convert the change in vehicle travel to a change in emissions using the emission factors calculated with the method in Chapter 7.

Toll roads and distance-based charges

Step 1: Estimate vehicle travel on the priced facilities (vehicle km/year). For toll roads, annual traffic volume data are required. For distance-based charges, data are required for the subset of the vehicle fleet that is subject to the charges, such as heavy goods vehicles.

Step 2: Estimate the fractional increase in driving costs, considering both fuel cost and the toll charge per kilometre. The fuel cost is a function of the per-litre cost of fuel and the vehicle fuel economy (calculated using the method in Chapter 8). Use equations 10.4 and 10.5.

[71] GIZ (2015a).

Equation 10.4: Estimate the fractional increase in driving costs

$$\text{Fuel cost per km} = \text{fuel price per litres} \times \text{fuel economy (litres per km)}$$

$$\text{Increase in driving costs} = \text{toll increase (per km)} / (\text{existing toll per km} + \text{fuel cost per km})$$

Step 3: Apply a price elasticity of vehicle travel to the increase in driving costs estimated in step 2, and multiply by the vehicle travel estimated in step 1, using equation 10.5.

Equation 10.5: Estimate change in vehicle travel

$$\text{Change in vehicle travel (km)} = \text{vehicle travel elasticity} \times \text{increase in driving costs (\%)} \times \text{vehicle travel (km)}$$

The fuel price elasticities presented in Chapter 8 are not directly applicable to toll roads or distance-based charges. In the case of fuel price increases, consumers can respond by choosing more fuel-efficient vehicles and/or driving less. With toll roads and distance-based charges, driving less is the main response. Thus, the vehicle travel elasticity in step 3 will be lower than those presented in Chapter 8.

If local elasticities are available, these can be used in step 3. Otherwise, multiply the fuel price elasticity from Chapter 8 by 0.45.[72] For example, if the fuel price elasticity is –0.30, the vehicle travel elasticity would be –0.30 × 0.45 = –0.135.

The assumption is that substitution effects shown in the causal chain are small.

Step 4. Convert the change in vehicle travel to a change in emissions, using the emission factors calculated with the method in Chapter 7.

10.3.4 Advanced approaches for calculating GHG impacts of road pricing

More advanced approaches can be used to estimate the GHG impacts of road pricing policies. In general, a regional travel demand model will be required that can predict the impact of different prices on travel,

[72] Goodwin, Dargay and Hanly (2004). The mean fuel consumption elasticity is –0.64, while the vehicle kilometre elasticity is –0.29.

mode share and congestion. For further information, refer to the following:

- Börjesson, Maria, Karin Brundell-Freij and Jonas Eliasson (2014). Not invented here: transferability of congestion charges effects. *Transportation Research Part A: Policy and Practice*, vol. 36, pp. 263–271.

- Eliasson, Jonas, and others (2013). Accuracy of congestion pricing forecasts. *Transportation Research Part A: Policy and Practice*, vol. 52, pp. 34–46.

- GIZ (2015a). *Introduction to Congestion Charging: a Guide for Practitioners in Developing Cities*.[73]

[73] Available at: www.adb.org/publications/introduction-congestion-charging-guide-practitioners-developing-cities.

PART IV

Monitoring and reporting

11 Monitoring performance over time

Monitoring serves two objectives: evaluation of the policy's performance (monitor trends in performance parameters to understand whether the policy is on track and being implemented as planned) and estimation of the policy's GHG impacts. This chapter provides guidance on how to develop a monitoring plan, and identifies data and parameters to monitor over time. Users who are estimating ex-ante GHG impacts without monitoring performance can skip this chapter.

Checklist of key recommendations

- Identify the key performance indicators that will be used to track performance of the policy over time and define the parameters necessary to estimate GHG emissions ex-post
- Create a plan for monitoring key performance indicators and parameters
- Monitor each of the indicators and parameters over time, in accordance with the monitoring plan

11.1 Identify key performance indicators and parameters

To estimate ex-post GHG impacts, users collect data on a broad range of indicators and parameters to be monitored during the implementation period. A key performance indicator is a metric that indicates the performance of a policy (such as tracking changes in targeted outcomes). A parameter is a variable such as activity data or an emission factor that is needed to estimate emissions.

It is a *key recommendation* to identify the key performance indicators that will be used to track performance of the policy over time and define the parameters necessary to estimate GHG emissions ex-post. These should be directly linked to the ex-ante assessment where they are used to monitor progress against such an assessment. The selection of indicators and parameters should be tailored to the policy, the needs of stakeholders, the availability of existing data, and the cost of collecting data. Table 11.1 provides examples of key performance indicators for pricing policies covered by this methodology, and Tables 11.2, 11.3 and 11.4 provide a summary of the relevant parameters for each approach presented in Chapters 7 and 8.

Some of the indicators and parameters listed in the tables also serve as inputs to monitor progress towards achieving national GHG reduction targets, such as NDCs, and meeting the reporting requirements of the transparency framework.

Tables 11.2, 11.3 and 11.4 summarize the specific parameters for approaches A, B and C used in Chapters 7 and 8. The parameter type refers to the data that are needed to monitor these parameters, which may be measured, estimated, modelled or calculated. The uncertainty can be determined by the user. It is specific to the context of the policy and differs for each parameter.

FIGURE **11.1**

Overview of steps in the chapter

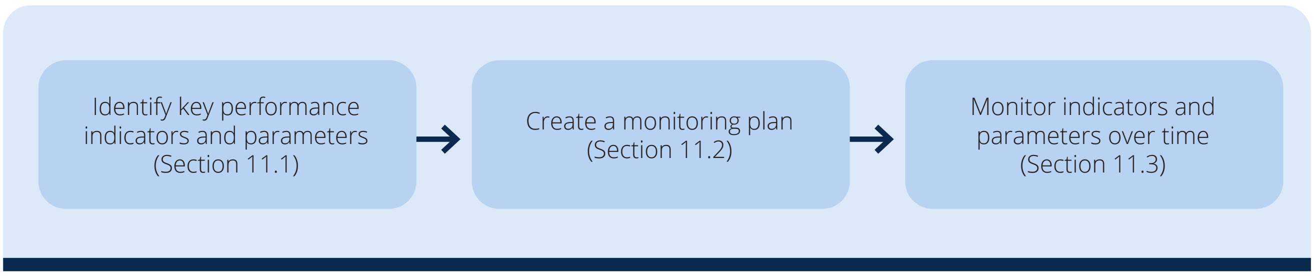


TABLE **11.1**

Key performance indicators for pricing policies

Key performance indicator	Definition	Examples
Inputs	Resources that go into implementing a policy	• Tax or subsidy removal
Activities	Administrative activities involved in implementing the policy	• Vehicle fleet composition: share of road transport (LDV/HDV) vs rail transport • Number of trips per mode • Changes in VKT • Passengers per m^2 • Tax revenue generated
Intermediate effects	Changes in behaviour, technology, processes or practices	• (Intermediate) supply and demand changes of shares of different vehicle types and sizes • Technological progress
Sustainable development impacts	Changes in relevant environmental, social or economic conditions that result from the policy	• Environmental: emissions of air pollutants; air pollutant concentration • Social: available income to (low-income) households after transport costs • Economic: amount of investment in public transport infrastructure

Source: Adapted from WRI (2014).
Abbreviation: VKT, vehicle kilometres travelled

TABLE **11.2**

Approach A – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Potential sources of data	Parameter type	Suggested monitoring frequency
Total fuel used for ground transport in year *y* (all fuel types) **F_y [TJ]**	In order of preference: • national energy balance or similar national energy statistics • data-collection process • international sources, such as IEA and IRENA	Measured/ estimated	Annual
Share of fuel type *i* in ground transport combustion, on an energy basis (i.e. expressed in units of energy – TJ) **S_i [%]**	In order of preference: • national statistics • indicative national reports or studies; expert estimate • assumption of a share of 50% diesel and 50% gasoline, in the absence of any suitable national information	Measured/ estimated	Annual

TABLE **11.2,** continued

Approach A – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Potential sources of data	Parameter type	Suggested monitoring frequency
Emission factor for fuel type *i* **EF_i [tCO_2/TJ]**	In order of preference: • national energy or environmental statistics • national fuel providers, such as refineries or fuel importers, based on their measurements • default values – diesel: 74.1 tCO_2/TJ/; gasoline: 69.3 tCO_2/TJ/[a]	Measured	Every 5 years
Fuel mix price elasticity **$\varepsilon_{fuel\ mix}$ [-]**	In order of preference: • country-specific data from empirical study or from literature • default values provided in methodology	Measured/ estimated	Once
Average fuel price, including price increase through policy **Fuel price [US$]**	National statistics	Measured	Annual
Total GHG emissions within assessment boundaries of the approach **Total emissions [tCO_2]**	Calculated using methodology	Calculated	Annual

[a] Both values are from IPCC (2006), vol. 2, Chapter 3, Table 3.2.1.

TABLE **11.3**

Approach B – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Potential sources of data	Parameter type	Suggested monitoring frequency
Total gasoline fuel used for ground transport in year *y* **$F_{G,y}$ [TJ]**	In order of priority: • national energy balance or similar national energy statistics • data-collection process • international sources, such as IEA	Measured/ estimated	Annual
Total diesel fuel used for ground transport in year *y* **$F_{D,y}$ [TJ]**		Measured/ estimated	Annual
Density of fuel type *i* **ρ_i [kg/m^3]**	In order of priority: • national energy statistics • reliable international sources • default values – diesel: 835 kg/m^3 at 15°C;[a] gasoline: 720 kg/m^3 at 15°C[b]	Measured	Once

TABLE **11.3,** continued

Approach B – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Potential sources of data	Parameter type	Suggested monitoring frequency
NCV of fuel type *i* **NCV_i [TJ/Gg]**	In order of priority: • national energy statistics • reliable international sources • default values – diesel: 43.0 TJ/Gg; gasoline: 44.3 TJ/Gg[c]	Measured	Once
Emission factor for gasoline fuel **EF_G [tCO_2/TJ]**	In order of priority: • national energy or environmental statistics • national fuel providers, such as refineries or fuel importers, based on their measurements • default values – gasoline: 69.3 tCO_2/TJ; diesel: 74.1 tCO_2/TJ[d]	Measured	Once
Emission factor for diesel fuel **EF_D [tCO_2/TJ]**		Measured	Once
Gasoline price elasticity **$\varepsilon_{gasoline}$ [-]**	In order of preference: • country-specific data from empirical study or from literature • default values provided in methodology	Measured/ estimated Uncertainty high	Once
Diesel price elasticity **ε_{diesel} [-]**		Measured/ estimated Uncertainty high	Once
Gasoline price, including price increase through price-based policy **Gasoline price [US$]**	National statistics	Measured	Annual
Gasoline price, including price increase through policy **Diesel price [US$]**	National statistics	Calculated	Annual
Total emissions from the combustion of gasoline within assessment boundaries of the approach **Gasoline emissions [tCO_2]**	Calculated using methodology	Calculated	Annual
Total GHG emissions from the combustion of diesel within assessment boundary of the approach **Diesel emissions [tCO_2]**	Calculated using methodology	Calculated	Annual

[a] Directive 1998/69/EC (www.dieselnet.com/standards/eu/fuel_reference.php).
[b] NOAA (no date).
[c] Both values are from IPCC (2006), vol. 2, Chapter 1, Table 1.2.
[d] Both values are from IPCC (2006), vol. 2, Chapter 3, Table 3.2.1.

TABLE **11.4**

Approach C – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Source of data	Parameter type	Suggested monitoring frequency
Vehicle kilometres travelled (with fuel type *i*, mode *j*, in year *y*) $d_{i,j,y}$ **[VKT]**	$d_{gasoline,car,y}$: gasoline-powered passenger cars • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (traffic counting, odometer reading, appropriate vehicle stock data) $d_{diesel,bus,y}$: diesel-powered passenger buses • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national surveys (traffic counting, odometer reading, appropriate vehicle stock data)	Measured/ estimated	Annual
Average (per VKT) number of persons travelling in same vehicle (with mode *j* in year *y*) $l_{j,y}$ **[persons per vehicle]**	$l_{car,y}$: passenger cars • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys • Supra-regional default value (e.g. for continent); otherwise, global default value of 2 persons, including the driver[a] $l_{bus,y}$: passenger buses • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national surveys • Supra-regional default value (e.g. for continent); otherwise global default value of 40% of total capacity[a,b]	Measured/ estimated/ modelled	Every 5 years

TABLE **11.4**, continued

Approach C – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Source of data	Parameter type	Suggested monitoring frequency
Specific fuel consumption. Average consumption per VKT in municipal, regional or national fleet (with fuel type *i*, mode *j*, in year *y*) **$sfc_{i,j,y}$ [litre per VKT]**	**$sfc_{gasoline,car,y}$**: gasoline-powered passenger cars • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from manufacturers) • Supra-regional default values (e.g. for continent); otherwise, global default value for gasoline consumption of gasoline cars of 10 L per 100 km (assumption by the authors of this methodology, based on HBEFA[c]) **$sfc_{diesel,bus,y}$**: diesel-powered passenger buses • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from manufacturers) • Supra-regional default values (e.g. for continent); otherwise, global default value for diesel consumption of diesel buses of 50 L per 100 km (assumption by the authors of this methodology, based on HBEFA[c])	Measured/ estimated/ modelled	Every 5 years
Total fuel and electricity use for rail passenger transport (with fuel type *i* in respective year *y*) **$FC_{i,rail,y}$ [litres of diesel; MWh of electricity]**	**$FC_{diesel,rail,y}$**: diesel-powered passenger rail • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from transit companies) **$FC_{electricity,rail,y}$**: electricity-powered passenger rail • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national surveys (e.g. from transit companies)	Measured/ estimated/ modelled	Annual
Distance travelled. Ideally, PKM are available separately for diesel and electricity travel. Otherwise, estimate total PKM travelled in rail passenger transport (in respective year *y*) **$PKM_{rail,y}$ [PKM]**	**$PKM_{rail,\,y}$**: PKM rail • Municipal, regional or national statistics or studies (from transit authorities) • Municipal, regional or national data-collection process or surveys (e.g. from transit companies)	Measured/ estimated/ modelled	Annual
Density of fuel type *I* **ρ_i [kg/m³]**	In order of priority: • national energy statistics • reliable international sources • default values – diesel: 835 kg/m^3 at 15°C;[d] gasoline: 720 kg/m^3 at 15°C[e]	Measured	Every 5 years

TABLE **11.4,** continued

Approach C – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Source of data	Parameter type	Suggested monitoring frequency
NCV of fuel type *i* **NCV_i [TJ/Gg]**	In order of priority: • national energy statistics • reliable international sources • default values – diesel: 43.0 TJ/Gg; gasoline: 44.3 TJ/Gg[f]	Measured	Every 5 years
Emission factor for gasoline fuel ***EFG* [tCO_2/TJ]**	In order of priority: • national energy or environmental statistics • national fuel providers, such as refineries or fuel importers, based on their measurements • default values – gasoline: 69.3 tCO_2/TJ; diesel: 74.1 tCO_2/TJ[g]	Measured	Every 5 years
Emission factor for diesel fuel ***EFD* [tCO_2/TJ]**		Measured	Every 5 years
Emission factor for electricity **$EF_{electricity}$ [tCO_2/TJ]**	In order of priority: • national energy or environmental statistics (electricity mix) • national fuel providers, such as refineries or fuel importers, based on their measurements • supra-regional default value (e.g. for continent); otherwise, global default value – mainly conventional/fossil fuel electricity production: 110,000 kgCO_2/TJ; at least 50% renewable share: 220,000 kgCO_2/TJ[h]	Measured	Every 5 years
Gasoline price elasticity **$\varepsilon_{gasoline}$ [-]**	In order of preference: • country-specific data from empirical study or from literature • default values provided in methodology	Measured/ estimated Uncertainty high	Once
Bus cross-price elasticity **$\varepsilon_{cross,bus}$ [-]**		Measured/ estimated Uncertainty high	Once
Rail cross-price elasticity **$\varepsilon_{cross,rail}$ [-]**		Measured/ estimated Uncertainty high	Once
Gasoline price, including price increase through policy **Gasoline price [US$]**	National statistics	Measured	Annual

TABLE **11.4,** continued

Approach C – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Source of data	Parameter type	Suggested monitoring frequency
Total passenger kilometres with passenger cars in road transport within assessment boundaries of the approach **Passenger kilometres with gasoline-powered passenger cars [PKM]**	Calculated using methodology	Calculated	Annual
Total passenger kilometres with passenger buses using diesel in road transport within assessment boundaries of the approach **Passenger kilometres with diesel-powered passenger buses [PKM]**	Calculated using methodology	Calculated	Annual
Total passenger kilometres with passenger trains using diesel in rail transport within assessment boundaries of the approach **Passenger kilometres with diesel-powered passenger trains [PKM]**	Calculated using methodology	Calculated	Annual
Total passenger kilometres with passenger trains using electricity in rail transport within assessment boundaries of the approach **Passenger kilometres with electricity-powered passenger trains [PKM]**	Calculated using methodology	Calculated	Annual
Total GHG emissions from the combustion of gasoline in passenger car road transport within assessment boundaries of the approach **Passenger car emissions [tCO_2]**	Calculated using methodology	Calculated	Annual

TABLE **11.4**, continued

Approach C – summary of relevant parameters from Chapters 7 and 8

Parameter and unit	Source of data	Parameter type	Suggested monitoring frequency
Total GHG emissions from the combustion of diesel in diesel bus road transport within assessment boundaries of the approach **Passenger bus emissions [tCO_2]**	Calculated using methodology	Calculated	Annual
Total GHG emissions from the combustion of diesel in passenger rail transport within assessment boundaries of the approach **Diesel-powered passenger rail emissions [tCO_2]**	Calculated using methodology	Calculated	Annual
Total GHG emissions from the use of electricity in passenger rail transport within assessment boundaries of the approach **Electricity-powered passenger rail emissions [tCO_2]**	Calculated using methodology	Calculated	Annual
Total GHG emissions from road and rail passenger transport within assessment boundaries of the approach **Total passenger transport emissions [tCO_2]**	Calculated using methodology	Calculated	Annual

Abbreviation: VKT, vehicle kilometres travelled

[a] UNFCCC (2014).

[b] To estimate total capacity of bus transport, estimate fleet composition (i.e. categories of buses with specific capacity), multiply number of buses (category) by specific capacity (category), and sum the results of these calculations for all the categories within the fleet.

[c] HBEFA (2014).

[d] Directive 1998/69/EC (www.dieselnet.com/standards/eu/fuel_reference.php).

[e] NOAA (no date).

[f] Both values are from IPCC (2006), vol. 2, Chapter 1, Table 1.2.

[g] Both values are from IPCC (2006), vol. 2, Chapter 3, Table 3.2.1.

[h] Assumption by the authors of this methodology, based on UNFCCC (2014).

11.2 Create a monitoring plan

Monitoring during the policy implementation period serves two objectives:

- **to evaluate the performance of the policy** – monitor trends in performance parameters to understand whether the policy is on track and being implemented as planned
- **to estimate GHG impacts** – collect the data needed for ex-post assessment of GHG impacts.

To monitor progress and estimate GHG effects ex-post, users need to collect data on parameters during and/or after the policy implementation period. A monitoring plan is important to ensure that the necessary data are collected and analysed. It is a *key recommendation* to create a plan for monitoring key performance indicators and parameters. A monitoring plan is the system for obtaining, recording, compiling and analysing data and information important for tracking performance and estimating GHG impacts. Where feasible, users should develop the monitoring plan during the policy design phase (before implementation), rather than after the policy has been designed and implemented.

11.2.1 Monitoring period

The policy implementation period is the time period during which the policy is in effect. The assessment period is the time period over which the GHG impacts resulting from the policy are assessed. The monitoring period is the time period over which the policy is monitored. There can be multiple monitoring periods within the assessment period.

At a minimum, the monitoring period should include the policy implementation period. It is useful if the monitoring period also covers monitoring of relevant activities before implementation of the policy and post-policy monitoring of relevant activities after the implementation period. Depending on the indicators being monitored, it may be necessary to monitor some indicators over different time periods than others.

Users should strive to align the monitoring period with those of other assessments being conducted using other ICAT methodologies. For example, if assessing sustainable development impacts using the ICAT *Sustainable Development Methodology* in addition to assessing GHG impacts, the monitoring periods should be the same.

For further information on institutional arrangements for coordinated monitoring, as well as key elements of a robust monitoring plan and system, refer to Section 3.2.

11.3 Monitor indicators and parameters over time

It is a *key recommendation* to monitor each of the indicators and parameters over time, in accordance with the monitoring plan. The frequency of monitoring is dependent on user resources, data availability, feasibility, and the degree of uncertainty to be accounted for in reporting. The monitoring plan should include an iterative process for balancing these dependencies. Where monitoring indicates that the assumptions used in the ex-ante assessment are no longer valid, users should document the difference and account for the monitored results when updating ex-ante estimates or when estimating ex-post GHG impacts.

12 Reporting

Reporting the results, methodology and assumptions used is important to ensure that the impact assessment is transparent, and gives decision makers and stakeholders the information they need to properly interpret the results. This chapter provides a list of information that is recommended for inclusion in an assessment report.

Checklist of key recommendations

- Report information about the assessment process and the GHG impacts resulting from the policy (including the information listed in Section 12.1)

12.1 Recommended information to report

It is a *key recommendation* to report information about the assessment process and the GHG impacts resulting from the policy (including the information listed below[74]). Where two or more assessment guides are applied to the policy, the general information and policy description only need to be reported once. For guidance on providing information to stakeholders, refer to the ICAT *Stakeholder Participation Guide* (Chapter 7).

General information

- The name of the policy assessed
- The person(s) or organization(s) that did the assessment
- The date of the assessment
- Whether the assessment is an update of a previous assessment and, if so, links to any previous assessments

[74] The list does not cover all chapters in this document because some chapters provide information or guidance that is not relevant to reporting.

Chapter 2: Objectives of assessing the GHG impacts of pricing policies

- The objective(s) and intended audience(s) of the assessment

Chapter 4: Steps and assessment principles

- Opportunities for stakeholders to participate in the assessment

Chapter 5: Describing the pricing policy

- A description of the policy, including the information in Table 5.1. Whether the assessment applies to an individual policy or a package of policies; if a package is assessed, which policies are included in the package
- Whether the assessment is ex-ante, ex-post, or a combination of ex-ante and ex-post

Chapter 6: Identifying impacts: how pricing policies reduce GHG emissions

- A list of all GHG impacts of the policy, using a causal chain, showing which impacts are included in the GHG assessment boundary
- A list of potential GHG impacts that are excluded from the GHG assessment boundary, with justification for their exclusion
- The assessment period

Chapter 7: Estimating the baseline scenario and emissions

- The approach followed for estimating base year emissions (approach A, B or C)
- A description of the baseline scenario projection, based on expected developments in population and GDP
- A list of influencing policies and actions, including the information in Table 12.1

- The methods and assumptions used for the projection of each parameter value, including which other external influences were included, if any, and a general description of the expected development of the parameter (see Table 12.2 for an example)

- Parameter values and GHG emission estimates for each year based on projected parameter values, using methods set out in Sections 7.1 and 7.2; reported as a time series using Table 12.3, including any available historical data, and indicating which data are historical and which are projected

TABLE **12.1**

Reporting on influencing policies and actions (example)

Influencing policy or actions	Implementation period for policy (start date, duration)	Description of potential effect on transport sector	Deviation from trend?	Magnitude of effect (major, moderate, minor)	Likelihood of effect (very likely, likely, possible, unlikely, very unlikely)
Import duty based on vehicle age and emission control technology	Planned start date: 1 June 2017 No end date	Improvement of average vehicle fleet efficiency Reduced growth in vehicle ownership per capita	Yes	Moderate	Likely

TABLE **12.2**

Reporting on parameter assumptions and expected developments (example)

Parameter	General description of expected development	Method used	External influences included?	Sources
Fuel use	Fuel use is expected to grow with a constant factor	Adjusted trend	Technology improvement with a constant efficiency gain of X%/year Income elasticity of fuel of 1.7	Using European Union data from European Environment Agency; literature review

TABLE **12.3**

Reporting on parameter values and baseline emissions

Parameter	Unit	Year 1 (historical)	Year 2 (projection)	Year 3 (projection)	Year 4 (projection)	Year *n* (projection)
Baseline emissions	tCO_2					
Fuel use (total)	MJ					
Fuel use (gasoline)	MJ					
Fuel use (diesel)	MJ					

- The method or approach used to assess uncertainty
- An estimate or description of the uncertainty and/or sensitivity of the results, to help users of the information properly interpret the results

Chapter 8: Estimating GHG impacts ex-ante

- Results of the GHG impact calculations and related uncertainties
- Any methodologies and assumptions used to estimate GHG emissions, including any models used
- All sources of data used to estimate parameters, including activity data, emission factors and assumptions
- The method or approach used to assess uncertainty
- An estimate or description of the uncertainty and/or sensitivity of the results, to help users of the information properly interpret the results

Chapter 9: Estimating GHG impacts ex-post

- Total annual and cumulative policy scenario emissions over the GHG assessment period
- The methodology and assumptions used to estimate policy scenario emissions, including the emissions estimation methods (including any models) used
- All sources of data used to estimate key parameters, including activity data, emission factors, global warming potential values, and assumptions
- An estimate of the total cumulative GHG impacts of the policy over the assessment period, and disaggregated by each GHG source included in the GHG assessment boundary
- The method or approach used to assess uncertainty
- An estimate or description of the uncertainty and/or sensitivity of the results, to help users of the information properly interpret the results

Chapter 10: Estimating GHG impacts for vehicle purchase incentives and road pricing

- Where Chapter 10 is applied, the information recommended under "General information" above and Chapters 2, 3, 5, 6 and 11, in addition to an explanation of the approach and data used to calculate GHG impacts

Chapter 11: Monitoring performance over time

- A list of the key performance indicators used to track performance over time and the rationale for their selection
- Sources of key performance indicator data and monitoring frequency

Additional information to report (if relevant)

- How the policy is modifying longer-term trends in GHG emissions
- The economic, social and environmental (sustainable development), and transformational impacts of the policy
- The type of technical review undertaken (first, second or third party), the qualifications of the reviewers and the review conclusions. More guidance on reporting information related to technical review is provided in Chapter 9 of the ICAT *Technical Review Guide*.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APPENDICES

Appendix A: List of default values for price elasticities

This appendix provides a list of default price elasticities for a selection of countries.

TABLE **A.1**

Default values for price elasticities

Country	Price elasticity		Country	Price elasticity		Country	Price elasticity	
	ε_{gp}	ε_{dp}		ε_{gp}	ε_{dp}		ε_{gp}	ε_{dp}
Albania	−0.26	−0.13	**Georgia**	−0.26	−0.13	**Oman**	−0.52	−0.27
Algeria	−0.3	−0.22	**Germany**	−0.28	−0.38	**Pakistan**	−0.41	−0.22
Angola	−0.22	−0.22	**Ghana**	−0.26	−0.13	**Paraguay**	−0.22	−0.13
Argentina	−0.05	−0.22	**Greece**	−0.33	−0.44	**Peru**	−0.37	−0.43
Australia	−0.29	−0.65	**Guatemala**	−0.5	−0.22	**Philippines**	−0.35	−0.13
Austria	−0.54	−0.16	**Honduras**	−0.3	−0.13	**Poland**	−0.32	−0.13
Azerbaijan	−0.22	−0.22	**Hong Kong**	−0.12	−0.36	**Portugal**	−0.25	−0.29
Bahrain	−0.5	−0.19	**Hungary**	−0.32	−0.38	**Qatar**	−0.08	−0.15
Bangladesh	−0.09	−0.22	**Iceland**	−0.33	−0.38	**Romania**	−0.26	−0.13
Belarus	−0.26	−0.22	**India**	−0.36	−0.13	**Russia**	−0.1	−0.22
Belgium	−0.34	−0.38	**Indonesia**	−0.2	−0.38	**Saudi Arabia**	−0.09	−0.12
Benin	−0.26	−0.13	**Iran**	−0.2	−0.15	**Senegal**	−0.26	−0.13
Bolivia	−0.22	−0.22	**Iraq**	−0.09	−0.17	**Singapore**	−0.33	−0.12
Bosnia and Herzegovina	−0.26	−0.13	**Ireland**	−0.3	−0.38	**Slovakia**	−0.32	−0.38
Botswana	−0.26	−0.13	**Israel**	−0.23	−0.19	**Slovenia**	−0.33	−0.38
Brazil	−0.26	−0.32	**Italy**	−0.38	−0.24	**South Africa**	−0.26	−0.13
Brunei	−0.24	−0.27	**Japan**	−0.15	−0.26	**Spain**	−0.24	−0.38
Bulgaria	−0.26	−0.13	**Jordan**	−0.26	−0.22	**Sri Lanka**	−0.4	−0.17
Cambodia	−0.26	−0.13	**Kazakhstan**	−0.26	−0.22	**Sudan**	−0.26	−0.22

TABLE **A.1,** continued

Default values for price elasticities

Country	Price elasticity		Country	Price elasticity		Country	Price elasticity	
	ε_{gp}	ε_{dp}		ε_{gp}	ε_{dp}		ε_{gp}	ε_{dp}
Cameroon	–0.26	–0.13	**Kenya**	–0.26	–0.13	**Sweden**	–0.32	–0.25
Canada	–0.48	–0.74	**Korea, South**	–0.6	–0.38	**Switzerland**	–0.37	–0.43
Chile	–0.25	–0.13	**Kuwait**	–0.09	–0.02	**Syria**	–0.22	–0.22
China	–0.26	–0.22	**Latvia**	–0.32	–0.13	**Taiwan**	–0.69	–0.28
Colombia	–0.04	–0.22	**Lebanon**	–0.26	–0.22	**Tanzania**	–0.26	–0.13
Congo, Republic of	–0.26	–0.13	**Libya**	–0.09	–0.22	**Thailand**	–0.16	–0.23
Costa Rica	–0.44	–0.13	**Lithuania**	–0.32	–0.13	**Togo**	–0.26	–0.13
Cote d'Ivoire	–0.09	–0.46	**Luxembourg**	–0.33	–0.38	**Trinidad and Tobago**	–0.22	–0.27
Croatia	–0.32	–0.13	**Macedonia, Former Yugoslav Republic of**	–0.26	–0.13	**Tunisia**	–0.22	–0.28
Cuba	–0.26	–0.13	**Malaysia**	–0.13	–0.22	**Turkey**	–0.19	–0.13
Cyprus	–0.33	–0.38	**Malta**	–0.32	–0.13	**Ukraine**	–0.14	–0.17
Czech Republic	–0.32	–0.38	**Mexico**	–0.31	–0.3	**United Arab Emirates**	–0.26	–0.13
Denmark	–0.4	–0.2	**Moldova**	–0.26	–0.13	**United Kingdom**	–0.33	–0.38
Dominican Republic	–0.29	–0.13	**Mongolia**	–0.26	–0.13	**United States of America**	–0.3	–0.07
Ecuador	–0.18	–0.17	**Mozambique**	–0.26	–0.13	**Uruguay**	–0.26	–0.13
Egypt	–0.21	–0.22	**Myanmar**	–0.22	–0.13	**Uzbekistan**	–0.26	–0.22
El Salvador	–0.26	–0.13	**Namibia**	–0.33	–0.38	**Venezuela**	–0.14	–0.17
Eritrea	–0.26	–0.13	**Nepal**	–0.26	–0.57	**Vietnam**	–0.26	–0.22
Estonia	–0.32	–0.38	**Netherlands**	–0.34	–0.01	**Yemen**	–0.22	–0.22
Ethiopia	–0.26	–0.22	**New Zealand**	–0.1	–0.38	**Zambia**	–0.26	–0.13
Finland	–0.33	–0.05	**Nicaragua**	–0.26	–0.22	**Zimbabwe**	–0.22	–0.22
France	–0.35	–0.24	**Nigeria**	–0.22	–0.22			
Gabon	–0.22	–0.22	**Norway**	–0.28	–0.07			

Source: Dahl (2012).

Appendix B: List of literature on price elasticities

This appendix provides a list of the most relevant literature on price elasticities. References used in the methodology are listed in the References section.

TABLE **B.1**

Literature on price elasticities

Author	Title	Country	Data years	Own-price	Cross-price
APTA (2011)	*Potential Impact of Gasoline Price Increases on U.S. Public Transportation Ridership, 2011–2012*	USA	2000–2011		X
BITRE (2017)	Transport Elasticities Database	Global	Several	X	X
Dahl (2012)	Measuring global gasoline and diesel price and income elasticities	Global	1970–2010	X	
Davis and Kilian (2010)	*Estimating the effect of a gasoline tax on carbon emissions*	USA	2009	X	
GIZ (2013)	Transport Elasticities: Impacts on Travel Behaviour	Several	Several	X	X
Goodwin, Dargay and Hanly (2004)	Elasticities of road traffic and fuel consumption with respect to price and income: a review	USA, EU, Australia, Japan, OECD	1990–2003	X	
Hoessinger et al. (2014)	*Estimating the price elasticity of fuel demand with stated preferences derived from a situational approach*	Several	Several	X	
Litman (2013)	Understanding Price Elasticities and Cross-Elasticities	Several	Several	X	
Oum, Waters and Yong (1992)	*Concepts of price elasticities of transport demand and recent empirical estimates*	USA, Australia, UK	1970–1990	X	X
TRACE (1999)	Elasticity Handbook	EU	1998	X	X

Appendix C: Overview of pricing policies

This appendix provides an exhaustive overview of pricing policies in the transport sector, along with a summary of their impacts on vehicle travel and GHG emissions. Section 3.1 gives a condensed overview of pricing policies that are the focus of this methodology (in Table 3.1).

C.1 Reduction of fuel subsidies

Many jurisdictions subsidize vehicle fuel, either by charging less than international market prices for domestically produced fuel or by subsidizing fuel through taxes.[75] Many experts recommend reducing fuel subsidies as a way to reduce government cost burdens and the macroeconomic costs of importing petroleum, reduce pollution emissions, and allocate public resources more equitably (since fuel subsidies benefit higher-income households more than the poor).[76] Reducing fuel subsidies can significantly increase fuel prices.

Figure C.1 compares average gasoline prices around the world. Based on 2014 oil prices, gasoline was considered to have a high subsidy if it sold for less than $0.48 per litre (to cover petroleum production costs) and a moderate subsidy if it sold for $0.49–0.86 per litre (to cover petroleum and roadway production costs).

The four categories shown in this diagram are summarized as follows:

- **Country category 1 – high subsidies** (up to $0.48). The retail price of gasoline is below the price for crude oil on the world market.
- **Country category 2 – subsidies** ($0.49–0.85). The retail price of gasoline is at least as high as the price for crude oil on the world market and below the price in the United States.
- **Country category 3 – taxation** ($0.86–1.41). The retail price of gasoline is at least as high as the price in the United States and below the price in Poland. In November 2014, gasoline prices in Poland were the lowest in the European Union (EU). Prices in EU countries are subject to value-added tax (VAT), specific fuel taxes, and other country-specific duties and taxes. The EU sets minimum taxation rates for fossil fuels.
- **Country category 4 – high taxation** ($1.42 and higher). The retail price of gasoline is at least as high as the price in Poland. At these levels, countries are effectively using taxes to generate revenues and to encourage energy efficiency in the transport sector.

Vehicle travel and emissions impacts: Fuel subsidy reductions increase fuel prices. This tends to reduce vehicle travel, encourage more efficient driving, and encourage motorists to choose more fuel-efficient and alternative-fuel vehicles.

C.2 Fuel tax/levy

Many jurisdictions tax vehicle fuel. This can include general taxes that apply to many goods, and special taxes specific to vehicle fuel, sometimes dedicated (hypothecated) to roadway expenses. Fuel taxes can be increased, and indexed to inflation so that they increase automatically instead of requiring special action. Some studies suggest that the high fuel taxes in Europe, Japan and Korea are justified on economic efficiency grounds,[77] and are an efficient GHG emissions reduction strategy.[78]

Vehicle travel and emissions impacts: Fuel tax increases increase fuel prices (although a small portion of the tax increase may be absorbed by distributors), which tends to reduce vehicle travel, encourage more efficient driving, and encourage motorists to choose more fuel-efficient and alternative-fuel vehicles.

[75] ADB (2014).

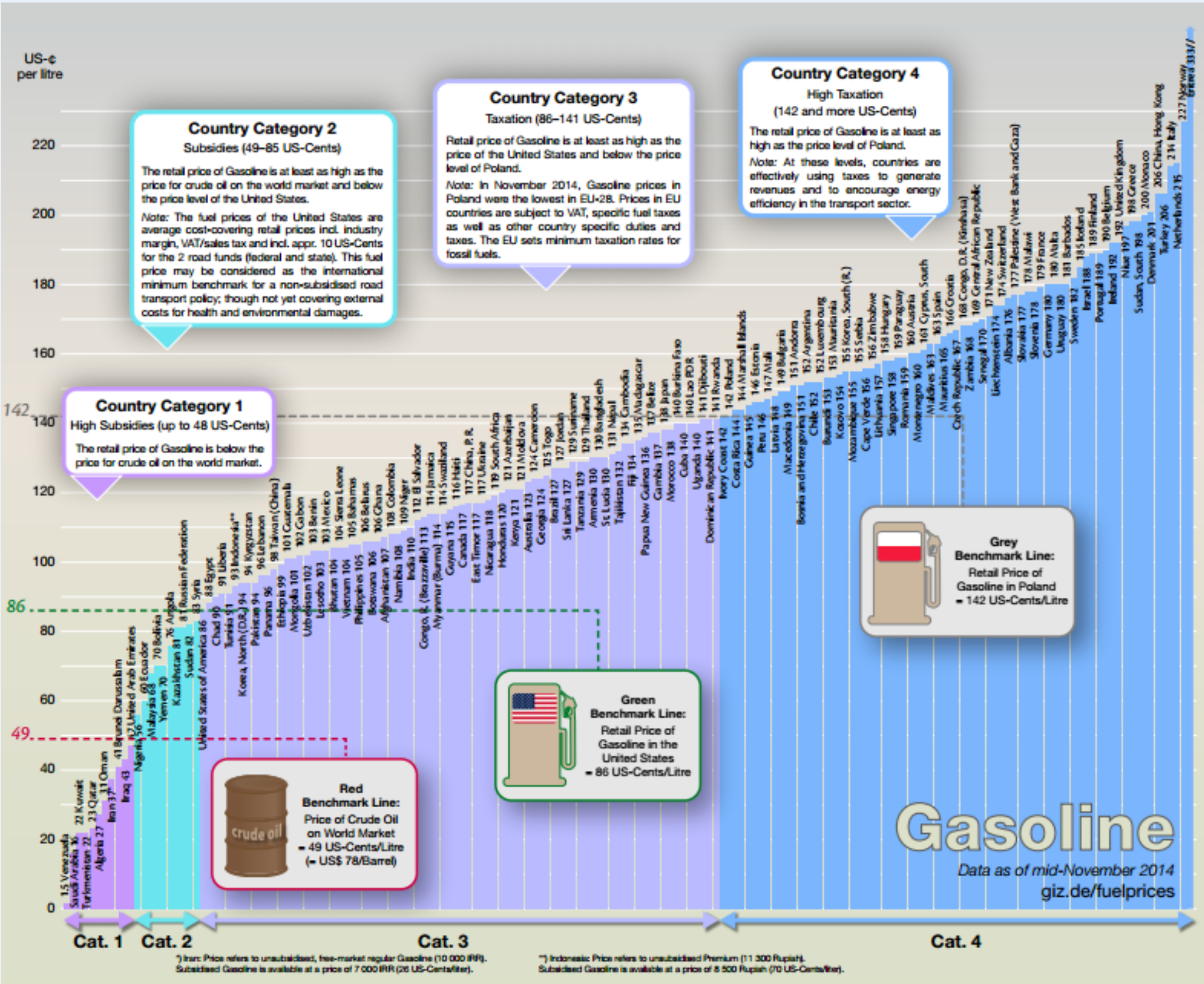
[76] Coady et al. (2010); GSI (2010); IEA (2013).

[77] Parry and Small (2004); Swiss ARE (2005); van Essen et al. (2007); Clarke and Prentice (2009).

[78] Sterner (2006).

FIGURE **C.1**

International gasoline prices



Source: GIZ (2015b).

C.3 Carbon tax (fuel taxes based on a fuel's carbon content)

Carbon taxes are taxes based on fossil fuel carbon content, and are therefore a tax on CO_2 emissions. They differ from fuel excise taxes, which are applied primarily to motor vehicle fuels as a way to finance highways and other transportation services. Because carbon taxes are intended primarily to internalize the environmental costs of fuel consumption and encourage energy conservation, there is no particular requirement for how their revenues should be used. Revenues can be used to reduce taxes, provide rebates or finance new public services, including energy conservation programmes.

If most revenues are returned to residents and businesses, resulting in no significant increase in total government income, the taxes are considered revenue neutral, called a "tax shift". Many economists advocate tax shifting to help achieve strategic policy objectives: raise taxes on "bads", such as pollution emissions, and reduce taxes on "goods", such as labour and investments.[79]

[79] Clarke and Prentice (2009).

Vehicle travel and emissions impacts: Carbon taxes increase fuel prices. The higher the carbon intensity of a fuel, the more prices per litre increase (i.e. larger relative price increases for diesel than for gasoline, and smaller increases for electricity; see the United States Environmental Protection Agency Greenhouse Gas Equivalencies Calculator[80]). This tends to reduce vehicle travel, encourage more efficient driving, and encourage motorists to choose more fuel-efficient and alternative-fuel vehicles.

C.4 Vehicle tax/levy

Most countries impose various taxes and fees on motor vehicle purchases and ownership. These can be structured in many ways that can affect vehicle travel and fuel consumption:

- Some cities use high fees to ration vehicle ownership. For example, Singapore auctions a limited number of Certificates of Entitlement, and some Chinese cities are applying similar systems.[81]
- Some countries have very high import duties on vehicles, which can reduce vehicle ownership, particularly if the country lacks domestic vehicle production.
- Many countries have vehicle taxes and fees that increase with vehicle weight or engine size, or fuel intensity.
- Some jurisdictions have vehicle taxes and fees that vary by fuel type.
- Some jurisdictions subsidize the purchase of low-carbon-fuel vehicles, including LPG and electricity.

Vehicle travel and emissions impacts: Very high vehicle ownership fees may reduce total vehicle ownership and use. High duties on imported vehicles may encourage motorists to retain older, often less efficient and less safe vehicles, or circumvent the rules by smuggling. Vehicle taxes and fees that vary by vehicle weight, engine size or fuel intensity can encourage motorists to purchase smaller and more fuel-efficient vehicles. Vehicle taxes and fees that vary by fuel type, or that subsidize low-carbon-fuel vehicles, can encourage motorists to choose lower-carbon-fuelled vehicles.

C.5 Road pricing (road tolls and congestion pricing)

“Road pricing” means that motorists pay directly for driving on a particular roadway or in a particular area. Road pricing has two general objectives: revenue generation (road tolls and distance-based vehicle fees that do not vary by time and location) and congestion management (congestion pricing, which applies higher prices for driving under congested conditions). Table C.1 compares these objectives.

TABLE **C.1**

Comparison of road pricing objectives

Revenue generation (road tolls and distance-based fees)	Congestion management (congestion pricing)
• Generates funds • Rates set to maximize revenue or recover specific costs • Revenue often dedicated to roadway projects • Shifts to other routes and modes not desired (because this reduces revenues[82])	• Reduced peak-period vehicle traffic • Is a travel demand management strategy • Revenue not dedicated to roadway projects • Requires variable rates (higher during congested periods) • Travel shifts to other modes and times considered desirable

[80] Available at: www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.

[81] Feng and Li (2013).

[82] Spears, Boarnet and Handy (2010).

Road tolls are widely used to finance highways and bridges, and some cities have implemented various types of congestion pricing.[83] Road pricing is sometimes criticized as unfair to lower-income commuters, but, on most urban corridors, only a small portion of motorists are in the low-income category, and road tolls are generally less regressive than other roadway funding options such as general taxes.[84]

Vehicle travel and emissions impacts: Revenue-generating tolls tend to reduce vehicle travel on affected roadways. Congestion pricing tends to reduce vehicle travel under congested conditions; by reducing congestion, it can provide additional energy conservation and emissions reductions. In most cases, these prices only apply to a minor portion of total vehicle travel, such as major new highways and bridges, or urban peak vehicle travel. As a result, although they may significantly reduce affected vehicles' travel and emissions, their total impacts are modest.

C.6 More efficient parking pricing (charging motorists for parking, and "cash out" parking so non-drivers receive comparable benefits)

"Parking pricing" means that motorists pay directly for using parking facilities.[85] It may be implemented to recover parking facility costs, as a parking management strategy (to reduce parking problems), as a travel demand management, management strategy, strategy (to reduce vehicle traffic), or downtown improvement district[86]), or for a combination of these objectives.[87] It can focus on various types of parking, such as on-street parking[88] or commuter parking.[89]

In most communities, the majority of parking is unpriced. Where users do pay, prices are often low or non-marginal – for example, with discounted annual or monthly rates. Many experts recommend more efficient pricing, with rates that increase with demand.[90]

Vehicle travel and emissions impacts: Parking pricing can have various travel and emissions impacts, depending on conditions:[91]

- High residential parking prices, with restrictions on on-street parking, may reduce vehicle ownership.
- Worksite parking pricing may cause some commuters to shift from driving to walking, cycling, ride sharing or public transit.
- Parking prices in a commercial district may cause some travellers to shift destinations, such as shopping at a mall rather than downtown.
- Parking prices at a particular location may cause some motorists to park elsewhere, if cheaper or free parking is available nearby.
- Some motorists may try to avoid parking prices by parking illegally.

Because parking facilities are costly (many parking spaces are worth more than most vehicles that occupy them), parking pricing can have large price effects and travel impacts.[92] In many situations, cost-recovery parking pricing would more than double the variable cost of driving. For example, cost-recovery prices for a typical commuter parking space would total $5–10 per day, which generally exceeds fuel costs for an average commute. As a result, parking pricing can be an effective strategy to reduce vehicle travel and emissions.

C.7 Distance-based vehicle insurance and registration fees

"Distance-based pricing" (also called "pay-as-you-drive" and "per-mile pricing") means that vehicle charges are based on the amount a vehicle is driven during a time period. Such fees tend to be more economically efficient and fair than existing pricing practices. Converting fixed costs into distance-based

83 Eliasson (2014); Van Amelsfort and Swedish (2015).

84 Schweitzer and Taylor (2008).

85 Shoup (2005).

86 In a downtown improvement district, vehicle owners pay an ad valorem tax (tax at the value of the property) for using parking spaces in a specific geographical area. This is an analogous concept to a business improvement district.

87 Weinberger, Kaehny and Rufo (2009).

88 SFPark (2012).

89 Rye and Ison (2005).

90 Barter (2010); FHWA (2012).

91 Vaca and Kuzmyak (2005); Litman (2010).

92 Hess (2001); Spears, Boarnet and Handy (2010).

charges (called "variabilization") gives motorists a new opportunity to save money when they reduce their annual travel. Below are examples of distance-based pricing:

- **Pay-as-you-drive vehicle insurance.** Insurance is one of the largest costs of owning a car, averaging about $750 per vehicle per year. Insurance premiums are generally considered a fixed cost, although the chances of having a crash increase with annual vehicle kilometres. A simple and effective way to make vehicle insurance distance based is to prorate existing premiums by vehicle kilometres, incorporating all existing rating factors.[93] With this system, a $375 annual insurance premium becomes a $0.03 per mile fee, and a $1,250 annual premium becomes a $0.10 per mile fee. This provides several benefits: more accurate insurance pricing; increased insurance affordability; a 10% reduction in total vehicle kilometres; a 12–15% reduction in vehicle crashes and insurance claims (it is particularly effective in reducing crashes because it gives the highest-risk motorists the greatest incentive to reduce annual vehicle kilometres); consumer cost savings (motorists are predicted to save an average of $50–100 annually in net insurance costs); and significant reductions in traffic congestion, road and parking facility costs, and pollution.

- **Distance-based registration fees.** This means that vehicle licensing and registration fees are prorated by vehicle kilometres, so a $60 annual licence fee becomes a $0.005 per mile charge, and a $240 annual licence fee becomes a $0.02 per mile charge. Similarly, other purchase and ownership fees, such as Singapore's vehicle quota charges, can be converted into variable fees.[94]

- **Distance-based vehicle purchase taxes.** Purchase taxes average about $1,200 per vehicle. These could be converted to distance-based taxes, which average about $0.01 per mile if paid over an average vehicle lifetime, or $0.03 per mile if paid over the first four years of a vehicle's operating life.[95] However, this may require monitoring of distances travelled per vehicle, which may not be feasible.

- **Distance-based vehicle lease fees.** Vehicle leases (which account for approximately 30% of new vehicle acquisitions in the United States) and rentals can be restructured to be more distance based. Although most leases and rentals include additional fees for "excessive driving", these are usually set at a high level and so only affect a minority of leased vehicle travel. Yet, analysis of the vehicle resale market indicates that virtually all kilometres driven increase vehicle depreciation, typically by $0.05–0.15 per additional vehicle mile. It makes sense that vehicle dealers reward their customers who minimize their vehicle travel on leased and rented cars with discounts.[96]

- **Weight–distance fees.** Weight–distance fees are a distance-based road use charge that increases with vehicle weight. The charge would range from about $0.035 per mile for automobiles up to $0.20 per mile for combination trucks. This is a more equitable way to fund roads than fuel taxes because it can more accurately represent the roadway costs imposed by individual vehicles.[97]

- **Distance-based emission fees.** Distance-based emission fees that reflect each vehicle's emission rate would give motorists with higher-polluting vehicles a greater incentive to reduce their vehicle travel, and, conversely, give motorists who must drive high annual kilometres an incentive to choose less polluting vehicles.[98] For example, in a particular area, an older vehicle that lacks current emission control equipment might pay $0.05 per mile, while a current vehicle might pay $0.02 per mile, and an ultra-low-emission vehicle might pay just $0.01 per mile. However, this may require monitoring of distances travelled per vehicle, which may not be feasible.

Vehicle travel and emissions impacts: The vehicle travel and emissions impacts of distance-based pricing can vary significantly depending on the strategy and the conditions under which it is

[93] Litman (1997); Ferreira and Minikel (2010); Greenberg (2013).

[94] Greenberg (2000); Barter (2010).

[95] Greenberg (2000).

[96] Greenberg (2000).

[97] Haldenbilen and Ceylan (2005).

[98] Sevigny (1998).

implemented. Since vehicle insurance, registration fees, purchase taxes and lease fees are relatively large, converting them to distance-based pricing can have large impacts on affected vehicles' travel and emissions (more than 10%, in some cases). If distance-based insurance is optional, it would probably affect a small portion of total vehicle travel, but if mandated could affect most or all private vehicles. Distance-based emission fees could provide proportionately larger reductions in emissions than in mileage, since vehicles with the highest emissions rates would be charged the highest per-kilometre fees, and so have the greatest incentive to reduce travel.

C.8 Public transit fare reforms (reduced and more convenient fares)

Public transit fare reforms can include reduced fares, free transfers, universal transit passes (e.g. all students at a university or all employees at a worksite receive transit passes), and more convenient payment systems (e.g. passes, electronic payment cards, mobile telephone payment systems).

Vehicle travel and emissions impacts: Although most transit travel has relatively low price elasticities, some pricing reforms can have relatively large impacts on travel.[99] For example, universal transit passes can significantly increase affected travellers' transit travel.

C.9 Company car tax reforms (reduced tax structures that encourage employers to subsidize employees' car travel)

A significant portion of vehicle travel is by company cars – that is, vehicles purchased by companies for employees' use. Many employees consider a high-value company car a substitute for wages, resulting in less fuel-efficient vehicles that are driven greater distances than motorists would choose if they purchased vehicles and fuel themselves.[100] Since a significant proportion of the second-hand car market consists of ex-company cars, these policies tend to leverage long-term increases in fuel consumption. A European Commission study[101] found that most EU countries under-tax company cars, resulting in direct revenue losses that may approach 0.5% of EU GDP (€54 billion). As well, welfare losses from distortions of consumer choice are substantial, perhaps equal to 0.1–0.3% of GDP (€12–37 billion).

To encourage energy efficiency, in 2002, the United Kingdom (UK) implemented a new company car tax system in which the tax was based on the level of CO_2 emissions the cars produce.[102] Business mileage discounts were removed to eliminate the financial incentive, which existed under the old system, for some company car drivers to do unnecessary business miles. An evaluation study estimated that this reform has led to a reduction in business miles being travelled in company cars in the UK in 2002/03 of 300–400 million miles and that this will continue in subsequent years. This represents a reduction in CO_2 emissions equivalent to about 0.1% of all CO_2 emissions from road transport in the UK. However, a review of the UK tax reform[103] found that it significantly increased diesel car purchases. Since company cars represent 55% of new car sales, this has led to a major shift towards diesel in the UK car stock as a whole, which is considered environmentally harmful. In 2010, a modification to the company car taxation system was introduced, which provided a step change incentive for drivers of low- and ultra-low-carbon vehicles. This change provides a financial advantage for hybrid and electric vehicles, which makes them the dominant clean vehicle technology.

Vehicle travel and emissions impacts: In countries where company cars are a significant portion of new vehicles and are more energy-intensive than motorists would choose for privately purchased vehicles, company car tax reforms can reduce total vehicle travel and emissions. However, such policies must be carefully structured to avoid undesirable consequences, such as the purchase of diesel vehicles.

C.10 Smart Growth pricing reforms

Smart Growth pricing reforms charge higher fees for sprawled development, reflecting the higher costs of providing public infrastructure and services to

99 McCollom and Pratt (2004).

100 Rivers et al. (2005).

101 Næss-Schmidt and Winiarczyk (2009).

102 HMRC (2004).

103 Potter and Atchulo (2012).

more dispersed locations. Sprawled development increases many environmental, social and economic costs, including per capita costs to governments of providing public infrastructure and services (e.g. water, sewage, roads, emergency services, school transportation); direct costs to consumers from increased motor vehicle travel; and increased external traffic costs, including congestion, accidents and pollution emissions.[104] Residents of more compact, infill development typically drive significantly less and produce fewer transport emissions than similar households located in automobile-dependent urban fringe areas.[105]

Experts find that development policies in most jurisdictions underprice sprawl – for example, by failing to charge residents for the higher costs of public infrastructure and services.[106] Several studies have calculated the additional fees that should be charged for sprawled, automobile-dependent development.[107]

Vehicle travel and emissions impacts: Smart Growth pricing reforms, which charge lower development fees and utility charges for buildings located in more compact areas, and implement effective traffic, parking and stormwater management systems that reduce infrastructure burdens, can result in significantly more accessible, multi-modal communities where residents drive less (often 40–60% less) and consume less energy than they would in more automobile-dependent urban fringe locations.

104 Ewing and Hamidi (2014); Litman (2014); Libertun de Duren and Compeán (2015).

105 Ewing and Cervero (2010); Boarnet and Handy (2014); Mehaffy (2015).

106 Blais (2010).

107 Stantec Consulting (2013); SGA (2015); City of Calgary (2016).

Appendix D: Overview of revenue impacts of pricing policies

Table D.1 provides an overview of the potential revenue impacts of pricing policies. Impacts of revenue use are discussed in Sections 3.1 and 6.1.

TABLE **D.1**

Potential revenue impacts of pricing policies

Pricing policy	Possible revenue uses	Travel and emissions impacts	Other impacts
Reduced fuel subsidies	Frees up public funds to reduce taxes or invest in other services.	Varies	Varies. By reducing vehicle travel, it provides traffic reduction benefits.
Carbon taxes	Can be used to reduce other taxes (revenue neutral) or invested in other services, including energy conservation programmes.	Can provide particularly large emissions reductions if a portion of revenues is invested in emissions reductions programmes.	Varies. By reducing vehicle travel, it provides traffic reduction benefits.
Increased fuel taxes	Can contribute to general funds, or be invested in roads or other transport modes.	If invested in roadway expansion, may increase total vehicle travel and emissions. If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.
Increased vehicle taxes	Can contribute to general funds, or be invested in roads or other transport modes.	If invested in roadway expansion, may increase total vehicle travel and emissions. If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.
Efficient road pricing	Can be invested in roads or other transport modes.	If invested in roadway expansion, may increase total vehicle travel and emissions. If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.
Efficient parking pricing	Can be invested in parking facilities, invested in other transport modes, or help finance other local government services.	If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes, can significantly reduce traffic problems and improve mobility for non-drivers.

TABLE **D.1,** continued

Potential revenue impacts of pricing policies

Pricing policy	Possible revenue uses	Travel and emissions impacts	Other impacts
Distance-based pricing	Generally, revenue neutral. Savings to motorists who drive less than average are offset by higher fees paid by those who drive more than average.	Reduces vehicle travel and emissions.	Can reduce traffic problems and provide savings to people who drive less than average annual kilometres.
Public transit fare reforms	Often requires subsidies.	Increases transit travel and reduces automobile travel.	Can reduce traffic problems and improve mobility for non-drivers.
Company car policy reforms	Mixed	Generally reduces total vehicle travel.	Can reduce car ownership and use.
Smart Growth reforms	Mixed. May increase revenues from sprawled-location residents.	Reduces local vehicle travel.	Reduces sprawl costs and improves accessibility for non-drivers.

Appendix E: ASIF terminology

The ASIF framework describes the four components that determine the transport sector's GHG emissions. ASIF stands for "activity" (trips, in km per mode), "structure" (modal share), "intensity" (energy intensity by mode, in MJ/km) and "fuel" (carbon intensity of the fuel, in $kgCO_2/MJ$). It was developed to provide an easily understandable framework for bottom-up methodologies in the transport sector.

Table E.1 provides the key indicators for transport MRV using the ASIF framework.

TABLE **E.1**

Key indicators for transport MRV using the ASIF framework

Data type	A-S-I-F	Category of data	General Indicators	Options for further differentiation
Top-down	Emission factors for fuels **(F)**	Carbon content	• NCV of fuel ($kgCO_2/MJ$) for each fuel type • Grid emission factors for electricity	• Correction factors for indirect emissions (based on life cycle assessment) • Fuel quality (e.g. sulfur content)
Bottom-up	Activity **(A)** and modal shift **(S)**	Fleet composition	• Number of vehicles by vehicle type (e.g. car, truck, motorcycle)	• Vehicle class or engine size • Vehicle age or technology
		Distance travelled	• Vehicle kilometre by vehicle type (in VKT) • Passenger kilometre (PKM) • Tonne kilometre (TKM)	• Mode • Vehicle class or engine size • Vehicle age or technology
		Trips	• Number of trips • Tonnes transported • Trip length	• By mode • By trip purpose (e.g. work, leisure)
		Load factor	• Occupancy (in persons/vehicle) • Load of goods vehicles (in %)	• Mode • Vehicle class or engine size
	Intensity **(I)**	Fuel consumption	• Fuel consumption (in L/km or kWh/km) by vehicle type	• Vehicle class (size is usually related to weight) • Vehicle age and engine technology (e.g. European standards) • Speed and/or congestion on the road (level of service) • Load (for trucks • Gradient (for trucks) • Aerodynamic design and rolling resistance of tyres

Source: Adapted from GIZ (2016), Section 2, p. 17, Table 2.

Appendix F: Method for estimating global default cross-price elasticities for approach C

In contrast to approaches A and B, approach C separately quantifies the GHG impacts from mode shifts through cross-price elasticities of gasoline. The availability of alternatives greatly amplifies the impacts of pricing policies.

The steps below give detailed information on how the global default cross-price elasticity values were estimated:

Step 1: Literature analysis

The authors of this methodology conducted an extensive literature search for suitable studies on mode shift and cross-price elasticities (see Appendix B for a list of further reading). No complete and comprehensive data set of cross-price elasticities is currently accessible. As a baseline for setting up a model defining global default values, the authors decided to use the cross-price elasticities for bus and rail described in a study by the American Public Transport Association.[108] The cross-price elasticities for rail had to be averaged over several (United States [US]–specific) rail transport categories.

However, there is specific literature on cross-price elasticities for selected countries. Where this is the case, countries are advised to use the country-specific values.

Step 2: Choose suitable descriptive parameters

The cross-price elasticity values assumed for the US are not applicable globally and need to be adjusted for applicability in other countries according to suitable descriptive parameters. Such parameters are defined in a paper on gasoline and diesel own-price elasticities:[109] (1) **fuel price** and (2) **average per capita income**. The authors assumed that these parameters could also be used to estimate cross-price elasticities.

[108] APTA (2011).

[109] Dahl (2012).

Step 3: Adjust the US-specific cross-price elasticity values for global applicability

The basis for the adjustment of the US-specific cross-price elasticity values is the table on own-price gasoline elasticities adapted from Dahl (2012) (see Table 8.4). The authors assumed that the influence of gasoline price and per capita income on the cross-price elasticity is exactly the same as for the own-price elasticity.[110] Box F.1 illustrates how this was done.

[110] According to Dahl (2012).

BOX **F.1**

Adjusting the US-specific cross-price elasticity value to another country (example)

The objective is to adjust the US-specific cross-price elasticity value to country C. The average gasoline price and per capita income are known for both countries.

Parameters	United States	Country C
Gasoline price ($ per litre)	0.60	0.25
Income ($ per capita)	30,000	15,000
Gasoline own-price elasticity (according to Table 8.4)	–0.22	–0.11
Percentage difference	+50%	–50%

The table above shows that, corresponding with the parameters gasoline price and per capita income, country C has an own-price elasticity that is 50% lower than the equivalent value for the US. We now assume that the same ratio applies to cross-price elasticities. The US has the following fuel cross-price elasticities:[111]

- cross-price elasticity towards bus systems – **0.14**
- cross-price elasticity towards rail systems – **0.22**

By applying the ratio from above (–50%) to the US-specific cross-price elasticities, we get the cross-price elasticities we need for country C:

- cross-price elasticity towards bus transport = 0.14 × 0.5 = **0.07**
- cross-price elasticity towards rail transport = 0.223 × 0.5 = **0.11**

The example can be reproduced in Table 8.5 in Section 8.1.4. The values in grey represent the cross-price elasticities for the US.[112] The values in yellow represent the cross-price elasticities for country C. The cross-price elasticity values for any other country (with a specific gasoline price and per capita income) have been estimated according to the method described above.

TABLE **F.1**

Adjusting the US-specific cross-price elasticity value to another country (example)

Gasoline price (2016 $ per litre)	Income per capita (2016 $/population)		
	<12,000	12,000–24,000	>24,000
<0.30	Bus 0.09	Bus 0.07	Bus 0.14
	Rail 0.15	Rail 0.11	Rail 0.22
0.30–0.80	Bus 0.14	Bus 0.15	Bus 0.14
	Rail 0.22	Rail 0.24	Rail 0.22
>0.80	Bus 0.16	Bus 0.20	Bus 0.21
	Rail 0.25	Rail 0.31	Rail 0.32

111 APTA (2011).

112 APTA (2011).

Appendix G: Stakeholder participation during the assessment process

This appendix provides an overview of the ways that stakeholder participation can enhance the process for assessment of GHG impacts of transport policies. Table G.1 provides a summary of the steps in the assessment process where stakeholder participation is recommended and why it is important, noting where relevant guidance can be found in the ICAT *Stakeholder Participation Guide*.

TABLE **G.1**

List of steps where stakeholder participation is recommended in the impact assessment

Chapter/step in this document	Why stakeholder participation is important at this step	Relevant chapters in *Stakeholder Participation Guide*
Chapter 2 – Objectives of assessing the GHG impacts or pricing policies	• Ensure that the objectives of the assessment respond to the needs and interests of stakeholders	Chapter 5 – Identifying and understanding stakeholders
Chapter 3 – Overview of transport pricing policies	• Identify the full range of stakeholder groups affected by, or with influence over, the policy • Enhance coordination of the assessment by considering different stakeholder perspectives and knowledge	Chapter 5 – Identifying and understanding stakeholders Chapter 6 – Establishing multi-stakeholder bodies
Chapter 4 – Using the methodology • Section 4.2.5 – Planning stakeholder participation	• Build understanding, participation and support for the policy among stakeholders • Ensure conformity with national and international laws and norms, as well as donor requirements relating to stakeholder participation • Identify and plan how to engage stakeholder groups who may be affected or may influence the policy • Coordinate participation at multiple steps for this assessment with participation in other stages of the policy design and implementation cycle, and other assessments	Chapter 4 – Planning effective stakeholder participation Chapter 5 – Identifying and understanding stakeholders Chapter 6 – Establishing multi-stakeholder bodies Chapter 9 – Establishing grievance redress mechanisms
Chapter 6 – Identifying impacts: how pricing policies reduce GHG emissions	• Improve and validate causal chain with stakeholder insights on cause–effect relationships between the policy, behaviour change and expected impacts	Chapter 8 – Designing and conducting consultations
Chapter 7 – Estimating the baseline scenario and emissions	• Inform assumptions on expected effects of existing and planned policies	Chapter 8 – Designing and conducting consultations

TABLE **G.1**, continued

List of steps where stakeholder participation is recommended in the impact assessment

Chapter/step in this document	Why stakeholder participation is important at this step	Relevant chapters in *Stakeholder Participation Guide*
Chapter 10 – Estimating GHG impacts for vehicle purchase incentives and road pricing	• Improve and validate causal chain with stakeholder insights on cause–effect relationships between the policy, behaviour change and expected impacts	Chapter 8 – Designing and conducting consultations
Chapter 11 – Monitoring performance over time	• Ensure that monitoring frequency addresses the needs of decision makers and other stakeholders	Chapter 8 – Designing and conducting consultations
Chapter 12 – Reporting	• Raise awareness of benefits and other impacts to build support for the policy • Inform decision makers and other stakeholders about impacts to facilitate adaptive management • Increase accountability and transparency, and thereby credibility and acceptance of the assessment	Chapter 7 – Providing information to stakeholders

Appendix H: Selecting the scope of the methodology

The scope of this methodology was selected using a set of criteria developed with the TWG:

- demand from countries
- potential for strong mitigation impact/large-scale transformation
- availability of international default data
- ability to strengthen national-level transport MRV systems
- potential for successful development of low-complexity methodology
- lack of existing methodology.

Abbreviations and acronyms

ASIF	activity (A), structure (S), intensity (I), fuel (F)
CH_4	methane
CNG	compressed natural gas
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
CPI	consumer price index
EU	European Union
GDP	gross domestic product
Gg	gigagram
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GJ	gigajoule
Gt	gigatonne
HDV	heavy-duty vehicle
ICAT	Initiative for Climate Action Transparency
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
IRENA	International Renewable Energy Agency
kt	kilotonne
LCU	local currency unit
LDV	light-duty vehicle
LPG	liquefied petroleum gas
MJ	megajoule
MRV	monitoring, reporting and verification
Mt	megatonne
MWh	megawatt-hour
NCV	net calorific value
NDC	nationally determined contribution
N_2O	nitrous oxide
OECD	Organisation for Economic Co-operation and Development
PKM	passenger kilometres
PPP	purchasing power parity
TJ	terajoule
TKM	tonne kilometres
TWG	Technical Working Group
UNFCCC	United Nations Framework Convention on Climate Change
VKT	vehicle kilometres travelled

Glossary

Assessment period	The time period over which GHG impacts resulting from a policy are assessed
Assessment report	A report, completed by the user, that documents the assessment process, and the GHG, sustainable development and transformational impacts of a policy
Baseline scenario	A reference case that represents the events or conditions most likely to occur in the absence of a policy (or package of policies) being assessed
Causal chain	A conceptual diagram tracing the process by which a policy leads to impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships
Cross-elasticity of demand	The responsiveness of the quantity demanded for a good to a change in the price of another good, all other things being equal. The cross-price elasticity is used to estimate the indirect impact, or the gross effect, of a fuel price increase on transport demand in alternative modes. It is the percentage change in a good's demand divided by the percentage change in a substitute good's price.
Emission factor	A factor that converts activity data into GHG emissions data
Ex-ante assessment	The process of estimating expected future GHG impacts of a policy (i.e. a forward-looking assessment)
Ex-post assessment	The process of assessing historical GHG impacts of a policy (i.e. a backward-looking assessment)
Expert judgment	A carefully considered, well-documented qualitative or quantitative judgment made in the absence of unequivocal observational evidence by a person or persons who have a demonstrable expertise in the given field[113]
GHG assessment boundary	The scope of the assessment in terms of the range of GHG impacts that is included in the assessment
GHG impacts	Changes in GHG emissions by sources that result from a policy
Heavy-duty vehicle (HDV)	A vehicle designed for heavy work (bus or truck), which is generally powered by a diesel engine
Impact assessment	Estimation of changes in GHG emissions or removals resulting from a policy, either ex-ante or ex-post
Independent policies	Policies that do not interact with each other, such that the combined effect of implementing the policies together is equal to the sum of the individual effects of implementing them separately

[113] IPCC (2006).

Inputs	Resources that go into implementing a policy, such as financing
Interacting policies	Policies that produce total effects, when implemented together, that differ from the sum of the individual effects had they been implemented separately
Intermediate effects	Changes in behaviour, technology, processes or practices that result from a policy, which lead to GHG impacts
Jurisdiction	The geographic area within which an entity's (such as a government's) authority is exercised
Key performance indicator (indicator)	A metric that indicates the performance of a policy
Light-duty vehicle (LDV)	Any motor vehicle with a gross vehicle weight rating of 10,000 pounds or 4,500 kg or less, which generally use gasoline fuel
Monitoring period	The time over which a policy is monitored, which may include pre-policy monitoring and post-policy monitoring in addition to the policy implementation period
Negative impacts	Impacts that are perceived as unfavourable from the perspective of decision makers and stakeholders
Overlapping policies	Policies that interact with each other and that, when implemented together, have a combined effect less than the sum of their individual effects when implemented separately. This includes both policies that have the same or complementary goals (e.g. national and subnational energy efficiency standards for appliances) and counteracting or countervailing policies that have different or opposing goals (e.g. a fuel tax and a fuel subsidy).
Own-price elasticity	The own-price elasticity is used to estimate the direct impact, or the net effect, of a fuel price increase on fuel demand. It is the percentage change in a good's demand divided by the percentage change in that good's price.
Parameter	A variable such as activity data or emission factors that are needed to estimate GHG impacts
Policy implementation period	The time period during which a policy is in effect
Policy or action	An intervention taken or mandated by a government, institution or other entity, which may include laws, regulations and standards; taxes, charges, subsidies and incentives; information instruments; voluntary agreements; implementation of technologies, processes or practices; and public or private sector financing and investment
Policy scenario	A scenario that represents the events or conditions most likely to occur in the presence of a policy (or package of policies) being assessed. The policy scenario is the same as the baseline scenario except that it includes the policy (or package of policies) being assessed.
Positive impacts	Impacts that are perceived as favourable from the perspectives of decision makers and stakeholders

Price elasticity of demand	A measure of the responsiveness of demand or supply of a good or service to changes in price. The price elasticity of demand measures the ratio of the proportionate change in quantity demanded to the proportionate change in the price.
Pricing policy	Pricing policies in the transport sector incorporate external costs of transport into price signals that are intended to influence demand and reduce GHG emissions. They include increased fuel taxes and levies, fuel subsidy reductions, road pricing, vehicle purchase incentives, carbon taxes, vehicle taxes, parking pricing, distance-based pricing, public transit fare reforms, company car policy reforms and Smart Growth reforms.
Rebound effect	Increased consumption that results from actions that increase efficiency and reduce consumer costs
Stakeholders	People, organizations, communities or individuals who are affected by, and/or who have influence or power over, a policy
Sustainable development impacts	Changes in environmental, social or economic conditions that result from a policy, such as changes in economic activity, employment, public health, air quality and energy security
Uncertainty	(1) Quantitative definition: Measurement that characterizes the dispersion of values that could reasonably be attributed to a parameter. (2) Qualitative definition: A general term that refers to the lack of certainty in data and methodological choices, such as the application of non-representative factors or methods, incomplete data or lack of transparency.

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