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Transport Pricing Methodology

Assessing the greenhouse gas impacts of transport pricing policies[1]

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1

Part I: Introduction, Objectives, Steps and Overview of Pricing Policies

1. Introduction

With the adoption of the Paris Agreement in 2015, governments around the world are increasingly focused on implementing policies and actions that achieve greenhouse gas (GHG) mitigation objectives. The transport sector is responsible for approximately 15% of global GHG emissions.[2] *Experts predict a potential doubling of transport activity by 2050 driven by economic growth. In this context, there is an increasing need to assess and communicate the impacts of transport policies and actions to ensure they are effective in delivering GHG mitigation and helping countries meet their sectoral targets and commitments.*

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. Additional methods are also provided in less depth on estimating the impacts of vehicle purchase incentives and road pricing policies.

This methodology is part of the Initiative for Climate Action Transparency (ICAT) series of methodologies for assessing the impacts of policies and actions. It is intended to be used in combination with any other ICAT guidance documents that users choose to apply. The series of methodologies is intended to enable users that choose to assess GHG impacts, sustainable development impacts 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 *Introductory Guide* for more information about the ICAT guidance documents and how to apply them in combination.

Intended users

This methodology is intended for use by policymakers and practitioners seeking to assess GHG impacts in the context of Nationally Determined Contribution (NDC) development and implementation, national low emission development strategies, and 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 on the assessment of GHG impacts. Impact assessment can also inform and improve the design and implementation of policies. Thus, the 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.

[2] SLoCaT 2017.

Scope and applicability of the methodology

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

- **Fuel subsidy removal**: Removal of subsidies that reduce the price of vehicle fuel below its fair-market cost.
- **Increased fuel tax or levy**: An increase in the tax imposed on each unit of vehicle fuel, which 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, and 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 of this guidance 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*[4] for descriptions and links to guidance on other transport policies or actions. Appendix H: Selecting the Scope of the lists the full criteria used to choose the scope of the methodology.

This methodology 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. Throughout the document, examples and case studies [*to be developed*] are provided to illustrate how to apply the methodology.

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

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[3] Throughout this methodology, 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 "policies or actions".

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

When to use the methodology

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

- **Before policy implementation**: To assess the expected future impacts of a policy (through ex-ante assessment)
- **During pricing policy implementation**: To assess the achieved impacts 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 first before implementation, regularly during policy implementation, and again after implementation. Users carrying out an ex-post assessment only skip Chapter 8. Users carrying out an ex-ante assessment only skip Chapter 9.

Key recommendations

The methodology includes *key recommendations* that represent recommended steps to follow when assessing and reporting impacts. These recommendations are intended to assist users in producing credible impact assessments that are high quality and 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 that want to follow a more flexible approach can choose to use the methodology without adhering to the key recommendations. The ICAT *Introductory Guide* provides further description of how and why key recommendations are used within the ICAT guidance documents, as well as more information about following either the "flexible approach" or the "key recommendations" approach when using the documents. Refer to the *Introductory Guide* before deciding on which approach to follow.

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,*[5] as well as additional resources listed in Appendix B: List of Literature on Price Elasticities.

The methodology builds upon the Greenhouse Gas Protocol *Policy and Action Standard*,[6] (which provides guidance on estimating the greenhouse gas impacts of policies and actions and discussion on many of the accounting concepts in this document such as baseline and policy scenarios), to provide a detailed method for specific transport pricing policies. As such, this methodology adapts the structure and some of the tables, figures and text from the *Policy and Action Standard* where relevant. Figures and tables

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

[6] WRI 2014. Available at: http://www.ghgprotocol.org/policy-and-action-standard.

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.

Alignment with the enhanced transparency framework of the Paris Agreement

This methodology can help countries in fulfilling 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 using indicators and parameters over time. 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., use 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 timeframe used to meet reporting requirements of the transparency framework (see Chapter 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).

Process for developing the methodology

This methodology has been developed through an inclusive, multi-stakeholder process convened by the Initiative for Climate Action Transparency (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 for the methodology through participation in regular meetings and written comments. A Review Group provided written feedback on the first draft of methodology.

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

ICAT's Advisory Committee provides strategic advice to the initiative. More information about the methodology development process, including governance of the initiative and the participating countries, is available on the ICAT website[7].

All contributors are listed in the "Contributors" section.

[7] https://climateactiontransparency.org/

2. Objectives of Assessing the 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 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* can be used to assess the broader sustainable development impacts of transport pricing policies and users should refer to that methodology for objectives for assessing such impacts.

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

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
- **Inform adjustments to policy design and implementation** and decide whether to continue current actions, enhance current actions, or implement additional actions
- **Learn from experience** and share best practices about policy impacts
- **Track progress toward national goals** such as NDCs and understand the contribution of policies toward achieving them
- **Inform future policy design**, including reformulation of NDCs toward 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 also identify the intended audience(s) of the assessment report. Possible audiences include policymakers, the general public, NGOs, 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 recent 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). In order to meet the ambitious target set forth 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, with the greater goal of decarbonization and transition to a "net-zero emission" economy, where remaining emissions from specific sectors are sequestered through other means.[8]

3.1 Pricing policies

Because they provide additional benefits besides GHG emission reductions, transport system changes can be considered win-win GHG emissions reduction solutions. Policies and actions that provide sustainable development benefits can be justified even where they have relatively high costs per unit of emission reduction. For example, high quality public transit systems have high costs and low direct emission reductions. However, 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 resulting from actions that increase efficiency and reduce 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 subsequent 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, which tends to overcharge owners of lower-annual-vehicle-kilometre vehicles and undercharge higher-annual-vehicle-kilometre vehicles compared with 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), given that the factors discussed in Section 3.1.2 and 3.1.4) are considered.

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 or alternative fuelled vehicles when

[8] SLoCaT 2017.

possible. A high fixed 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, ridesharing or using public transit instead of driving), where they travel (e.g., from a city centre to other destinations with cheaper parking), where they park (e.g., to the fringe of the city centre where parking is cheaper), or to find ways to circumvent the fees (e.g., parking illegally).[9] These factors are important to consider when evaluating a pricing policy's costs and benefits.

Motor vehicles tend to have high fixed and low variable costs, so 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 and residential parking), but only about USD 0.20[10] per kilometre in variable expenses (e.g., fuel and tire wear). Adding a daily parking fee or road toll of USD 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 a transit fare increase vary depending 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 at 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 and public transit) or used in other ways that benefit the poor, such as bus rapid transit systems funded by local fuel taxes or parking fees, pricing policies can be more effective at achieving social equity objectives.

The impacts of these policies depend on markets that change over time. For example, when choosing which vehicles to purchase, potential buyers may respond to fuel price increases by purchasing more efficient and alternative fuelled vehicles, or by choosing more city accessible homes that require less driving. In general, long-run elasticities are about three times as large as short-run elasticities. In the long-run, for example, where a fuel tax increase causes a 10% reduction in fuel consumption the first year, it should provide a 30% reduction over the long run (more than 5 years) if maintained in magnitude, accounting for inflation.[11] 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 their vehicle ownership after fuel prices have remained high for an extended period of time.

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

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[9] Litman 2016.

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

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

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 effect 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 emissions 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 Estimating GHG Impacts for Vehicle Purchase Incentives and Road Pricing and Appendix C: Overview of Pricing .

Table 3.1: Overview of pricing policies

Policy	Description	Vehicle travel and emission 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 priced below international crude oil prices, and moderately subsidized if priced below fuel production and roadway costs	• Increased fuel prices may lead to reduced vehicle travel and/or increased switching to more efficient and alternative fuelled 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 fuelled vehicles
Carbon taxes	Carbon taxes are based on a fuel's carbon content, and are therefore a tax on CO_2 emissions	• Increased fuel prices, with greater increases for more carbon-intensive fuels such as gasoline, lead to reduced vehicle travel and/or increased purchase of more fuel efficient and alternative fuelled 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, 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 low-carbon fuel

		vehicles 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 non-drivers receive comparable benefits	• Various impacts depending on conditions, including reduced vehicle ownership, modal shift, shift of destinations, shift in parking locations, 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, distance-based emission fees	• Various impacts depend significantly on the policy and its conditions
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 or 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 rather than higher-income populations. However, this is not necessarily the case. This perception is based on the 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. This is only the case where all households purchase the same transport-related goods and services. However, 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, transportation 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 less to disadvantaged people. Although transportation price increases often seem regressive, since a given tax or fee represents a larger portion for lower-income than higher-income households, they are generally less regressive than other transportation 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 of these 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 represent a hidden subsidy of driving. In such cases it is necessary to calculate the total amounts of subsidy and under-taxing, analyze 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.

Transportation pricing can be very progressive (i.e., significantly benefits disadvantaged people) if it includes need-based subsidies or discounts, so disadvantaged people pay less than advantaged people, or if revenues are used in ways that benefit disadvantaged groups, for example to support inclusive and affordable transportation options (walking, cycling, public transit and universal design features), or to reduce more regressive taxes such as property and sales taxes. Other public policies can help achieve transportation equity, for example by developing affordable housing in accessible urban locations so 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

There are several common elements of transport pricing policies that 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 along with complementary and reinforcing transport and land use emission reduction strategies, such as 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 speaking, 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 transport sector monitoring, reporting and verification (MRV) systems to support and improve policy planning, implementation and assessment activities with the underlying objective of enhancing the environmental, social and economic impacts of these 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 transport sector MRV system

The specific nature of a MRV system depends on whether countries have committed to an economy-wide target, a sector-wide mitigation target or individual mitigation policies and/or actions. While the assessment of a sectoral mitigation target necessitates a full inventory of GHG emissions, the assessment of a specific mitigation policy or action involves the estimation of 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 allows users to quantify and monitor emissions from different policies and actions in much more detail. Where possible, these two approaches should be aligned, since consistency is necessary for many steps undertaken in the assessment.

Because the transport sector involves a diverse array of interconnected activities, including policies that directly and indirectly affect one or more of the components, resulting 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 different 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 is needed, how data will be processed, and the responsible entities for the data collection, analysis and monitoring. Countries should use existing domestic arrangements, processes and systems already in place 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 assessment of GHG emissions reductions tracking. 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 sub-national level
- Assess progress on transport policies being implemented and identify where to focus new GHG emissions reductions 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 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 different 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. The institutional arrangements also depend on the scope of the MRV and whether it is of 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, 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. 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. The coordinating body may also oversee technical and institutional capacity building and monitor QC/QA standards with other participating institutions. This collaboration aims to maximize synergies, enhance efficiency and streamline the work between the institutions involved.

Where strong institutional arrangements do not yet exist, countries can determine and strengthen a governmental body to ensure it has the 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 on Establishing Institutional Arrangements for National Communications and Biennial Update Reports*[12], 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.

[12] 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 that are intended 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 4.1 for an overview of steps. Depending on when the methodology is applied and the approach chosen, users skip certain chapters.

Figure 4.1: Overview of steps

Part I: Introduction, objectives, steps and overview of transport 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)

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Part II: Defining the assessment

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

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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 using approach A, B or C (Chapter 8)
Assess GHG impacts ex-post (Chapter 9)

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Part IV: Monitoring and reporting

Identify parameters and monitor the performance over time (Chapter 10)
Report the results and methodology used (Chapter 11)

4.2 Planning for the assessment

Users should review this methodology, the *Introductory Guide* and other relevant guidance documents, and plan the steps, responsibilities and resources needed to meet their objectives for the assessment in advance. Identify in advance the expertise and data needed for each step, plan the roles and responsibilities of different actors, and secure 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 has already been collected, whether analysis related to the policy has previously been done, and the desired 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

There are a range of options 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 attributed to a specific policy, with a high level of certainty), while 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).

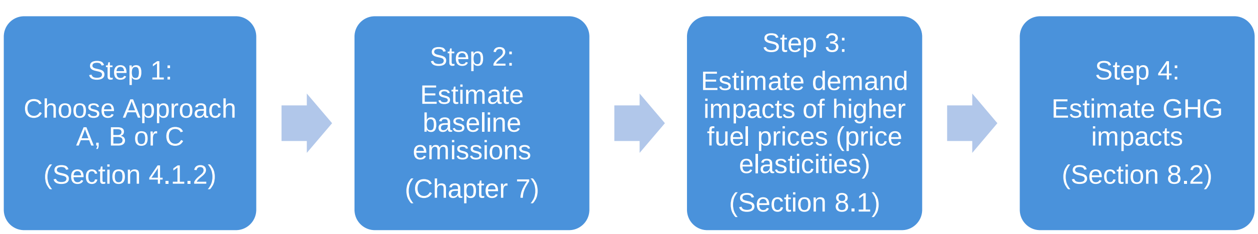
Users should choose approaches and methods that are sufficient to accurately meet the stated objectives of the assessment and ensure that the resulting claims are appropriate. For example, whether a policy contributes to achieving GHG emission reductions or whether emission reductions can be attributed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

4.2.2 Approaches for GHG impact assessment

The methodology outlines four principal steps for assessing the impacts of a policy, shown in Figure 4.2. Within each principal step, there are further steps users follow to calculate GHG impacts.

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

Figure 4.2: Four key steps for assessing the impacts of pricing policies



Chapters 7 - 9 provide methods for estimating the GHG impacts of pricing policies, while approaches for other 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, bus and rail-based public transport for users who have differentiated fuel mix data and data on passenger kilometres (PKM)[13] and tonne kilometres (TKM).[14] In the methodology, freight transport is excluded in order to keep the explanations and calculations simple. Users can apply the approach and include freight transport with TKM. However, when GHG impacts are assessed with 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 therefore provide a higher level of detail.

These approaches focus on gasoline and diesel. The same approaches could be used for other fuels (e.g., 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 GIZ *Reference Document on Measurement, Reporting and Verification in the Transport Sector* (Section 2.1) defines two types of datasets: top-down "energy use" and bottom-up "travel activity" data. Approaches A and B are based on the top-down approach, while Approach C is based on both the top-down and the bottom-up approach.

Comparison of the three approaches

The three approaches lead to different results. As you move from Approach A to C, the level of detail necessary for the assessment increases (i.e., 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 Approach A or B because it includes only passenger transport. Additionally, Approach C allows for the geographical system boundaries to be set for an urban context using rather than at the national level. By assessing several urban regions with Approach C, larger regions can be aggregated and analyzed. It is also possible to apply two different approaches (e.g., Approach B on the national level and Approach C for an urban region) in order to conduct a national assessment while still gaining valuable insights on the impacts of mode shift from Approach C. Through

[13] Passenger kilometres (PKM): Equals the numbers of passengers multiplied with kilometres travelled with a specific vehicle (vehicle kilometres). (e.g., if two people travel in one passenger car for 20 kilometres, this equals 2 pers. x 20 km = 40 PKM.)

[14] Tonne kilometres (TKM): Same concept as for PKM, but for freight and using the tonne unit (e.g., if 3 tonnes of a good are transported over a distance of 20 kilometres in a heavy duty vehicle, this equals 3 t x 20 km = 60 TKM).

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 and 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.

Table 4.1: Overview of approaches covered by the methodology

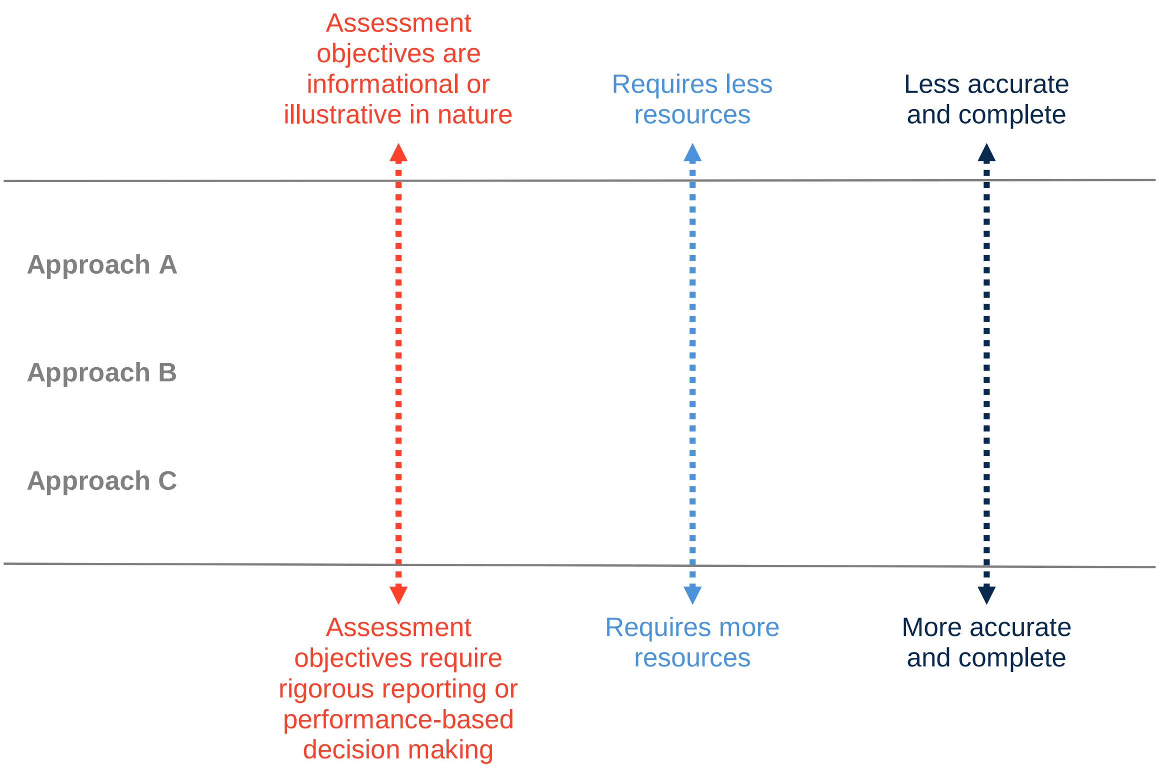
Approach	Data requirements	Boundaries / Coverage		
		Geographical system boundaries	Passenger / Freight	Fuel types
Approach A	Only general fuel consumption data (Basis for calculation: top-down energy use data)	National, subnational or municipal	Ground transport (passenger and freight)	Fuel mix (unspecified mix of gasoline, diesel and/or other transport fuels)
Approach 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
Approach C	Comprehensive bottom-up travel activity data (e.g., distance travelled by mode j) (Basis for calculation: top-down energy use 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

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 IPCC for emission factors and net calorific values (NCVs). For possible data sources for elasticity values see Appendix B: List of Literature on Price Elasticities. Section 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 prior to beginning an impact assessment. The approach should be selected based on the user's objectives, capacity and resources. 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 for assessing impacts and obtaining and estimating data.

Figure 4.3: 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 in order to complete an assessment where information is not available or requires. 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.[15] The goal is to be as representative as possible in order 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.

Expert judgement 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 they can be consulted to help select suitable values from a range of values. Expert judgement can be informed or supported through broader consultations with stakeholders.

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

[15] IPCC 2000.

4.2.5 Planning stakeholder participation

Stakeholder participation is recommended in many steps throughout the methodology. It can strengthen the impact assessment and the contribution of policies to GHG emission 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
- Raising awareness and enabling better understanding of complex issues for all parties involved, 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 enhance benefits for all stakeholder groups, including the most vulnerable
- Enhancing the credibility, accuracy and comprehensiveness of the assessment, drawing on diverse expert, local and traditional knowledge and practices, for example, to provide inputs on data sources, methods and assumptions
- Enhancing transparency, accountability, legitimacy and respect for stakeholders' rights
- Enabling enhanced ambition and financing by strengthening the effectiveness of policies and 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), reporting (Chapter 12).

Before beginning the assessment process, 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, as well as requirements of specific donors and of international treaties, conventions and other instruments that the country is party to. These are likely to include requirements for disclosure, impact assessments and consultations, and may include specific requirements for certain stakeholder groups (e.g., UN Declaration of the Rights of Indigenous Peoples, International Labour Organisation Convention 169).

During the planning phase, it is recommended to identify stakeholder groups that may be affected by or may influence the policy. Appropriate approaches should be identified to engage with the identified stakeholder groups, including through their legitimate representatives. To facilitate effective stakeholder participation, consider 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 advise and potentially contribute to decision making to 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 analyze 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: Stakeholder Participation During the Assessment Process summarizes the steps in this methodology where stakeholder participation is recommended along with specific references to relevant guidance in the *Stakeholder Participation Guide*.

4.2.6 Planning technical review (if relevant)

Before beginning the assessment process, 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 are intended to underpin and guide the impact assessment process, especially where the methodology provides flexibility. It is *a key recommendation* for the assessment to be based on the following five principles:[16]

- **Relevance**: Ensure 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 in the GHG assessment boundary, including both positive and negative impacts. Disclose and justify any specific exclusions.
- **Consistency**: Use consistent assessment approaches, data collection methods, and calculation methods to allow for 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

[16] Adapted from WRI 2014

process to derive the same results if provided with the same source data. Chapter 11 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 as to the integrity of the reported information. If accurate data for a given impact category is not currently available, users should strive to improve accuracy over time as better data becomes 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 to 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.

Box 4.1: Conservativeness

Conservative values and assumptions are those 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 in order to obtain unbiased results. The principle of relevance can help guide what approach to use and how conservative to be.

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 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 over or underestimate the impacts resulting from the combination of policies. For example, the combined impact of a local energy efficiency policy and a national energy efficiency policy in the same country is likely less than the sum of the impacts had they been implemented separately, since they affect the same activities. Chapter 4 provides more information on policy interactions.

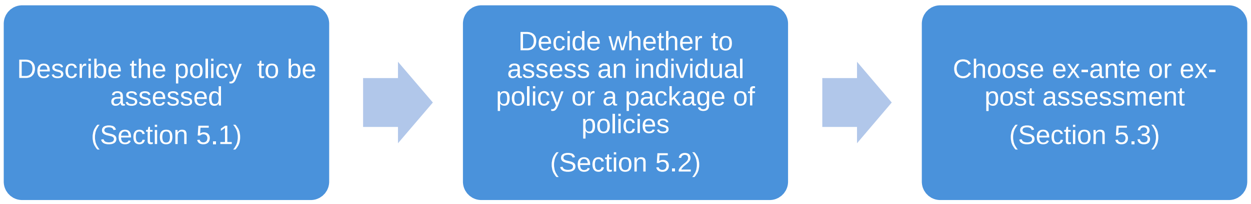
In practice, users may encounter trade-offs between principles when developing an assessment. For example, a user may find that achieving the most complete assessment requires using less accurate data for a portion of the assessment, which could compromise overall accuracy. Users should balance trade-offs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

Part II: Defining the Assessment

5. Describing the Pricing Policy

This chapter provides guidance on describing the policy. In order 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.

Figure 5.1: Overview of steps in the chapter



Checklist of key recommendations

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

5.1 Describe the policy to be assessed

In order to effectively carry out an impact assessment in subsequent chapters, it is necessary to have a detailed understanding of the policy being assessed. 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 that 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.

Table 5.1: Checklist of recommended information to describe the policy being assessed

Information	**Description**	**Example**
Title of the policy	Policy name	National Fuel Levy
Type of policy	The type of policy, per 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 and will be targeted at LDVs in the form of a fixed sum per litre, higher for gasoline than for diesel.

		Mean average income of USD 13,254 per capita and an annual mean fuel price of USD 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: 0.15 • Cross-price elasticity with respect to gasoline price, for rail (average): 0.24
Status of policy	Whether the policy is planned, adopted or implemented	Planned
Date of implementation	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)	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) the policy intends to achieve (e.g., the purpose stated in the legislation or regulation) To encourage individuals and industry to use less fossil fuel and to reduce GHG emissions	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
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, LDVs
Greenhouse gases targeted	Which GHG the policy aims to control, which may be more limited than the set of GHG 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 entitled Transport 2030 aims to plan regional systems across municipal borders, increasing ease and access to public transport. Public transport will also be subsidized through this policy in rural areas.

Table 5.2: Checklist of additional information that may be relevant to describe the policy being assessed

Information	Description	Example
Intended level of mitigation to be achieved and/or target level of other indicators (if applicable)	Target level of key indicators, if applicable	Target • 3-5% annual reductions in vehicle emissions compared to 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 monitoring, reporting, and verification procedures associated with implementing the policy	A data clearing house will be established and a coordinating body will oversee and monitor QC/QA standards with other participating institutions involved in data collection
Enforcement mechanisms	Any enforcement or compliance procedures, such as penalties for noncompliance	Enforcement mechanisms may be necessary

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
The broader context/significance of the policy	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	What are the sustainable development impacts of the policy?	Estimation of impact of policy, including the 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)	

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 timeframe, users can assess them either individually or as a package. When making this decision, consider the assessment objectives, the feasibility of assessing impacts individually or as a package, and the degree of interaction between the policies under consideration. Pricing policies may interact with other policies and actions. Elasticities are empirical values and implicitly take other policies into consideration. Where other policies have an impact on behaviours the impacts are represented in the elasticity. However, users can refer to the *Policy and Action Standard* for further general guidance on policy interactions and whether to assess an individual policy or a package of policies.

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 either apply 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. If 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. 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; or a combined ex-ante and ex-post assessment to estimate both the past and future impacts.

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

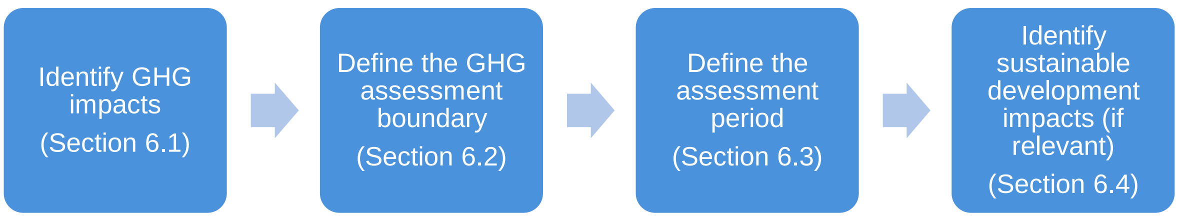
In most sectors, ex-ante assessment plays a role in planning for mitigation actions, but the focus of MRV is on ex-post assessments because it is only through ex-post assessment that all relevant data to determine the impact is available. The exact level of emission reductions can be quantified based on the actual measured data. For example, in a biomass energy project, it is only because the amount of biomass that has actually been used to substitute fossil fuels is known (ex-post) that the exact quantity of emission reductions resulting from this substitution can be determined with high accuracy (ex-post). The level of accuracy of ex-post assessments may be improved if detailed and elaborate models of transport are available.

The assessment of pricing policies on the basis of price elasticities is fundamentally different. After the implementation of the policy, 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 the implementation of the policy (e.g., actual fuel consumption) does allow for a plausibility check, but does 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.

Figure 6.1: Overview of steps in the chapter



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 for policies where significant impacts arise from the use of revenues.

6.1.1 Identify intermediate effects

In order to identify the GHG impacts of the 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, while 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. They can be categorized either by how stakeholders are expected to respond to the policy, or to the other intermediate effects of the policy, and can also include 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 the 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 as well as a shift to more efficient transport 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
- Increased fuel prices, with greater increases for more carbon-intensive fuels such as gasoline
- Reduced vehicle travel
- Increased switching to more efficient and alternative fueled vehicles
- Increased purchase of more fuel efficient and alternative fueled 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 emissions 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, construction industry, 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.

Table 6.1: Example GHG sources for fuel pricing policies

Source category	Description	Emitting entity or equipment	Relevant GHGs
Road transport, light duty vehicles (LDV)	Fuel combustion from light duty vehicles	Passenger vehicles, light duty trucks, motorcycles	CO_2
Road transport, heavy duty vehicles (HDV)	Fuel combustion from heavy duty vehicles	Heavy duty trucks and buses	CO_2
Rail transport	Fuel combustion and electricity use from locomotives	Diesel and electric locomotives	CO_2

Importance of how revenues from pricing policies are used

Impacts related to the use of available revenue generated from the policy cannot be quantified with the proposed calculations in this methodology. It is however crucial to bear in mind that the use of revenue has a significant influence on GHG impacts. 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, etc.
- Revenue neutral redistribution to households through:
- Lowering taxes, possibly increasing consumer spending and in turn increasing emissions from households
- Paying targeted subsidies to poor populations to provide a social cushion for subsidy removal
- Equal per capita redistribution
- Earmark for transport infrastructure, which tends to increase emissions if invested in roadways rather than public transport and bicycle lanes, among others.
- Earmark for 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, which may reinforce emission 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 further decrease or increase GHG emissions, or, 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.

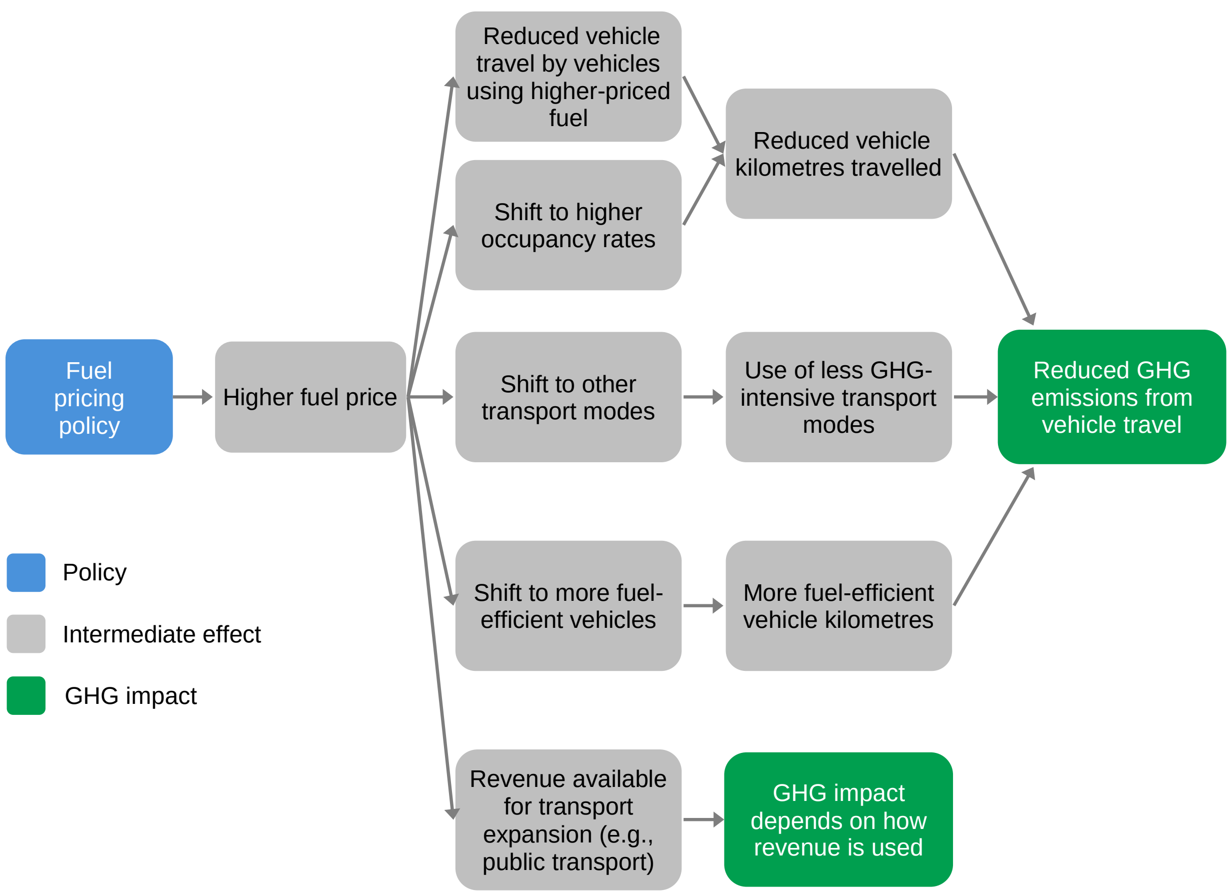
6.1.3 Develop a causal chain

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 on the policy can help with development and validation of the causal chain by integrating stakeholder insights on cause-and-effect relationships between the behaviour change 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.

Figure 6.2: Example causal chain for fuel pricing policies



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

Table 6.2: Example GHG impacts and source categories included/excluded in the GHG assessment boundary

GHG impact	GHG	Likelihood	Relative magnitude	Included?	Explanation
Reduced GHG emissions from reduced vehicle kilometres travelled (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 result in 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 compressed natural gas (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 the policy implementation and the quality and availability of substitutes, as well as consumer behaviour;

					considered significant for most fuel pricing policies
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 emission reductions decrease, since 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 emission reductions increase, since 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

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 *a key recommendation* to define the assessment period based on the time horizon of the GHG impacts included in the GHG assessment boundary of the policy.

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 or action is implemented and the date of the assessment or it can be a shorter period between those 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.

When defining the 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 toward 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 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, where 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 identifies examples of sustainable development impacts associated with pricing policies. Refer to the ICAT *Sustainable Development Methodology* to conduct a full assessment of sustainable development impacts of their policy.

Table 6.3: Examples of sustainable development impacts and indicators relevant to transport pricing policies

Examples of impact categories	Examples of indicators for each impact category
Environmental impacts	
Air quality and health impacts of air pollution (SDG 3, SDG 11, SDG 12)	• Emissions of air pollutants such as particulate matter (PM2.5, PM10), ammonia, ground-level ozone (resulting from volatile organic compounds (VOCs) and nitrogen oxides (NOx)), carbon monoxide, sulphur dioxide, nitrogen dioxide, fly ash, dust, lead, mercury, and other toxic pollutants (tonnes/year) • Air pollutants concentration (mg/m^3) • Aerosol particles concentration (mg/m^3) • Indoor and outdoor air quality • Morbidity (disability-adjusted life years (DALYs), quality-adjusted life year (QALY), and averted disability-adjusted life years (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	

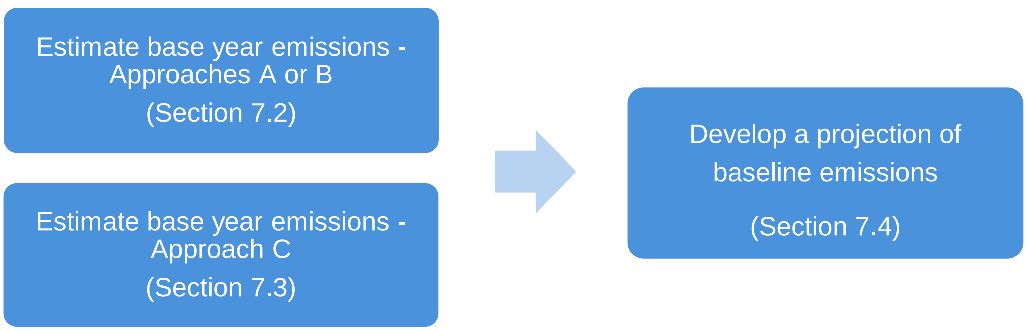
Illness and death (SDG 3)	• Life expectancy (years) • Avoided premature deaths per year • Morbidity (Disability-adjusted life years (DALYs), Quality-adjusted life year (QALY), and Averted disability-adjusted life years (ADALYs))
Mobility (SDG 11)	• Number of people or proportion of population with convenient access to employment, schools, healthcare, or recreation, by sex, age, and persons with disabilities
Traffic congestion	• Time lost during transportation • Economic cost of time lost
Road safety (SDG 3, SDG 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 (USD) 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

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.

Figure 7.1: Overview of steps



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 selected as the year in the assessment from which projections will be made into the future. Where the results of this 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, socio-economic 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.

The 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 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. Choose the appropriate approach based upon data and capacity available. The same baseline scenario applies for both Approaches A and B. Section 7.2 provides the guidance for Approaches A and B. Section 7.3 provides the guidance for Approach C.

Where applying Approach C, refer to Section 7.3 for guidance on defining the baseline scenario and calculating base year emissions for an individual year.

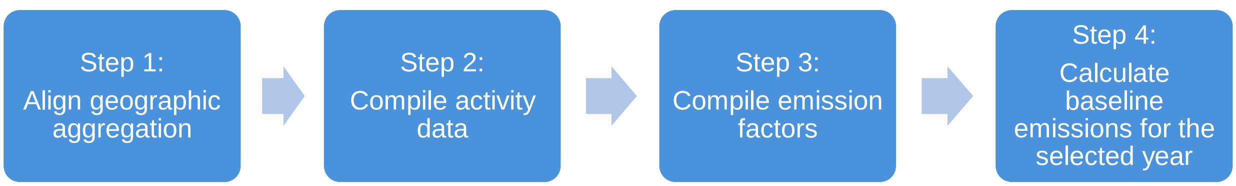
Approaches A and B use top-down, national data to estimate base year emissions for policies implemented at the national level. In contrast to Approaches A and B, Approach C is particularly suitable for the city level where activity data is available for activities (i.e., fuels used) within the city boundary.[17] In both cases, the baseline scenario is considered to be a continuation of the conditions that exist in the absence of the new policy. Calculate base year emissions 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, while the emission factor is related to the carbon content of the vehicle fuels utilized and is defined in 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

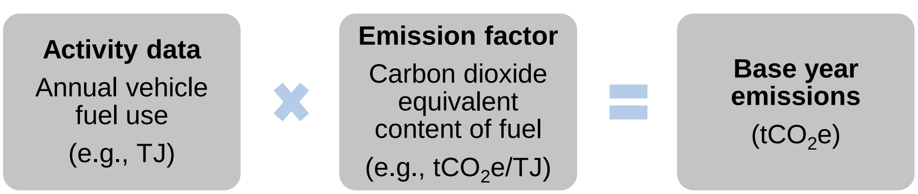
Figure 7.2 provides an overview of the steps for both Approaches A and B.

Figure 7.2: Overview of steps for Approach A



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 and may be 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.

Figure 7.3: Base year CO_2 emissions calculation for Approach A and B



If transport fuel contains 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 biogenic emissions from biofuels can be assumed to be zero. It should be considered in the applied emission

[17] 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. 2014. *Guidelines for Reporting Emissions and Projections Data under the Convention on Long-range Transboundary Air Pollution*. Available at: http://www.ceip.at/fileadmin/inhalte/emep/2014_Guidelines/ece.eb.air.125_ADVANCE_VERSION_reporting_guidelines_2013.pdf.

factor when calculating the emissions following Figure 7.3 above. 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 Chapter 11). A more comprehensive way to assess the emissions of biofuels within the ground transport system is depicted 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 calculate 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 with diesel fuel, Approach B should be applied.

Where this is the case, follow the four steps 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.[18]

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, it is also necessary to 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 in order 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 prior to applying the emission factor, for example using the method provided by the IPCC.[19]

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

[19] IPCC 2006. Available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/2_Volume2/V2_1_Ch1_Introduction.pdf#page=17. 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)".*

Data on total fuel use is 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 other similar governmental bodies may manage these data in some cases. 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 utilized in the country. Depending upon the sources (e.g., national production and/or imports), data can be derived from refineries, fuel importers and/or customs authorities. Users could also use well-designed and executed surveys of fuel distributors or fuelling stations to build the data set. In the latter case, it is recommended to 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) country statistics.[20]

For all data sources, analyze the compiled fuel use data while accounting for the following considerations:

- **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 vary considerably. 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 back-up 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 dataset 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, users can 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, as well as possible data sources.

[20] Available at: http://www.iea.org/statistics/.

Table 7.1: Activity parameter for Approach A

Parameter	Description	Units	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

For Approach A, since all fuel types are aggregated in the activity data, the user should 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 (i.e., 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 with possible data sources.

Table 7.2: Conversion factors for activity data for Approach A

Conversion factor	Description	Units	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, expert estimate • A share of 50% diesel and 50% motor gasoline may be assumed in the absence of any suitable national information

Step 3: Compile emission factors

The emission factors (EF_i) represent the amount of CO_2 emissions expected to result from combusting a unit of fuel, and are based on the total carbon content of the fuel. In Approach A, emissions of methane (CH_4) or nitrous oxide (N_2O) are ignored for simplification. Users should take into account the different transport fuels utilized 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 of this methodology, emission factors consider only tank-to-wheel emissions and no “upstream” or well-to-tank emissions.

Table 7.3 provides an overview of the emission factor parameters for Approach A with possible data sources.

Table 7.3: Emission factor parameters for Approach A

Parameter	Description	Units	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 and/or fuel importers, based on their measurements • Default values. Diesel: 74.1 tCO_2/TJ, Gasoline: 69.3 tCO_2/TJ (both IPCC 2006, Vol. 2 Ch. 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 the following equation. 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

$$Base\ year\ emissions\ for\ year\ y: \quad \boldsymbol{BE_y} = \sum\nolimits_i \boldsymbol{F_y}\,(in\ TJ)\ x\ \boldsymbol{S_i}\,(in\ \%)\ x\ \boldsymbol{EF_i}\,(\mathrm{in}\frac{tCO_2}{\mathrm{TJ}})$$

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

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

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 be targeted at 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, and 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 follows *Step 1. Align geographic aggregation* and determines 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 chooses to use the default values since other values are not available.

The Ministry staff determines 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 x 50% x 74.1 tCO_2/TJ) + (782,000 TJ x 50% x 69.3 tCO_2/TJ) = 28,973,100 tCO_2 + 27,096,300 tCO_2 = 56,069,400 tCO_2

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

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 calculate GHG impacts (CO_2 only) where separate data are available on the annual fuel consumption of gasoline and diesel. It is appropriate to use Approach B where separate data are available on annual fuel consumption of 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 a proxy for light duty vehicles (LDV) that tend to use gasoline, and heavy duty vehicles (HDV) that tend to use diesel. LDVs are vehicles with a gross vehicle mass (GVM) up to around 3,900 kg[21], such as typical passenger cars with a GVM of around 1,800 kg. They are utilized mainly for personal travel.

HDVs are vehicles with a higher gross vehicle mass that 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) versus commercial vehicles (HDV). Price elasticities are often different for these two groups of vehicles,[22] accounting for the fact that there is not perfect congruency between each 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 described in Step 1 of 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 the national borders.[23]

[21] US EPA. Available at: https://www.epa.gov/emission-standards-reference-guide/vehicle-weight-classifications-emission-standards-reference-guide The definition of the LDV category limits vary somewhat from country to country per regulations.

[22] Dahl 2012.

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

Step 2: Compile activity data

The activity data are comprised of 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, as long as disaggregated data are available. Users should obtain the 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 Section 7.1.

The third alternative is to use international sources, such as International Energy Agency country statistics.[24]

For all data sources, analyze the compiled fuel use data while accounting for the following considerations:

- **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 vary considerably. 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 back-up 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, users can report the related uncertainty but omit the consideration from the calculations.

During the compilation of activity data, it is also necessary to 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 in order 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 prior to applying the emission factor, for example using the method provided by the IPCC.[25]

Table 7.4 provides an overview of activity parameters for Approach B, as well as possible data sources.

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[24] Available at: http://www.iea.org/statistics/.

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

Table 7.4: Activity parameters for Approach B

Parameter	Description	Units	Sources
$F_{G,y}$	Total gasoline fuel used for ground transport in year *y*	TJ	In order of priority: • National energy balance or similar national energy statistics • Data collection process • International sources, such as IEA
$F_{D,y}$	Total diesel fuel used for ground transport in year *y*	TJ	

Where activity data are expressed in volume units (i.e., 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, including possible sources of data.

Table 7.5: Conversion factors for activity data for Approach B

Conversion factor	Description	Units	Sources
ρ_i	Density of fuel type *i*	kg/m^3	In order of priority: • National energy statistics • Reliable international sources[26] • Default values. Diesel: 835 kg/m^3 at 15°C (Directive 1998/69/EC)[27]. Gasoline: 720 kg/m^3 at 15°C (NOAA)[28]
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 (both IPCC 2006, Vol. 2 Ch. 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 $F_{i,y}$).

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[26] For more information on data collection, see the IPCC Guidelines available at: http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_2_Ch2_DataCollection.pdf

[27] DieselNet. Available at: https://www.dieselnet.com/standards/eu/fuel_reference.php.

[28] NOAA. Available at: https://cameochemicals.noaa.gov/chemical/11498.

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

$$\boldsymbol{F_{G,y}}\ in\ energy\ units\ (TJ)\ =\ \boldsymbol{FC_{G,y}}\ in\ volume\ units\ (L)\ x\ \rho_G\ x\ \ NCV_G\ \div\ 10^9$$

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

$$\boldsymbol{F_{G,y}}\ in\ energy\ units\ (TJ)\ =\ FC_{G,y}\ in\ mass\ units\ (Gg)\ x\ \ NCV_G$$

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 methane (CH_4) and nitrous oxide (N_2O) for simplification. 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 of this methodology, 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.

Table 7.6: Emission factor parameters for Approach B

<table>
<tr><th>Parameter</th><th>Description</th><th>Units</th><th>Sources</th></tr>
<tr><td>EF_G</td><td>Emission factor for gasoline fuel</td><td>tCO_2/TJ</td><td rowspan="2">In order of priority:
• National energy or environmental statistics
• National fuel providers, such as refineries and/or fuel importers, based on their measurements
• Default values. Gasoline: 69.3 tCO_2/TJ, Diesel: 74.1 tCO_2/TJ (both IPCC 2006, Vol. 2 Ch. 3 Table 3.2.1)</td></tr>
<tr><td>EF_D</td><td>Emission factor for diesel fuel</td><td>tCO_2/TJ</td></tr>
</table>

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 (*$BE_{i,y}$*) associated with that fuel type *i* for the year *y* under consideration.

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

$$Base\ year\ emissions\ from\ gasoline\ for\ year\ y:\quad \boldsymbol{BE_{gasoline,y}}\ =\boldsymbol{F_{G,y}}\ \ (in\ TJ)\ x\ \boldsymbol{EF_G}\ (\mathrm{in}\frac{tCO_2}{\mathrm{TJ}})$$

$$Base\ year\ emissions\ from\ diesel\ for\ year\ y:\quad \boldsymbol{BE_{diesel,y}} =\ \boldsymbol{F_{D,y}}\ (in\ TJ)\ x\ \boldsymbol{EF_D}\ (\mathrm{in}\frac{tCO_2}{\mathrm{TJ}})$$

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.

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 be targeted at 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, and 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 ($FC_{G,y}$) were used that year, and 8,000 Gg of diesel ($FC_{D,y}$). 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 follows *Step 1: Align geographic aggregation* and determines 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 x 44.3 TJ/Gg = 348,198 TJ *(Equation 7.3)*

$F_{D,y}$ = 8,000 Gg x 43.0 TJ/Gg = 344,000 TJ *(Equation 7.3)*

Under *Step 3: Compile emission factors*, the Ministry staff chooses to use the default values since other values are not available.

The Ministry staff determines 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 x 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 x 74.1 tCO_2/TJ = 25,490,400 tCO_2 (see Equation 7.4)

Thus, the result shows there are about 50 $MtCO_2$ emissions in the base year from the two fuels (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 both the assessment of a policy's impact on GHG emissions, and also the assessment of impacts 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 analyzed 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. For shifts to electric mobility, CNG or non-motorized transport, the method can be applied as well (if data is 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 utilizes both top-down energy use and bottom-up travel activity data to estimate base year emissions (see Section 4.2.2 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: a) freight transport cannot be assessed with the proposed calculation (though users can apply the approach to freight transport as well using different input data and cross-price elasticities), and b) 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 emission reductions achieved through the policy. However, the approach provides further information regarding mode shift.

The method is based on the ASIF terminology (see Appendix E ASIF Terminology 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 PKMs 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 Approach C base year emissions calculation formula. In addition to calculating total base year emissions, the base year emissions are also divided by PKM (see Figure 7.5) in order to obtain a ratio which can be used to quantify the impacts of the policy in Chapter 8.2.

Figure 7.4: Calculation of total base year GHG emissions for Approach C

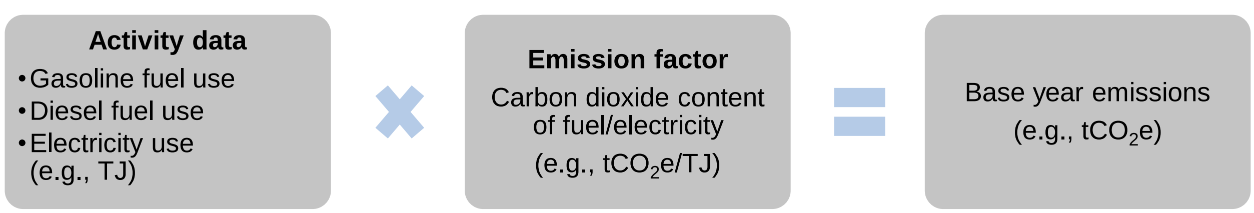
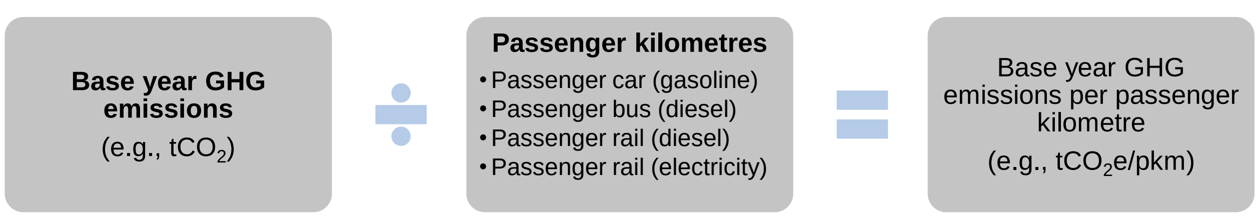


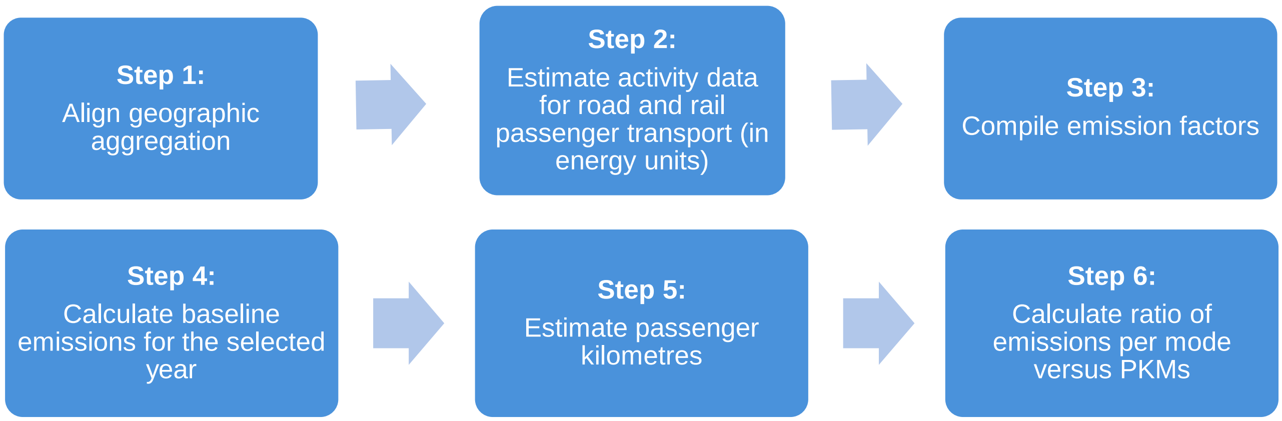
Figure 7.5: Calculation of base year GHG emissions per PKM



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 (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 emission calculation for the biofuel can be conducted with the analogous equations as for the fossil fuel share. If possible, country-specific emission factors (and where relevant NCVs) should be used. If such country-specific data is not available, the Renewable Energy Directive[29] (European Commission, 2009) provides default values that can be used.

For the calculation of base year emissions in passenger transport, follow the steps in Figure 7.6

Figure 7.6: Overview of steps for Approach C



Step 1. Align geographic aggregation

Follow the same approach as described for Approaches A and B in Step 1 of Section 7.2.1 to align the geographic aggregation of the activity data and the policy.

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.

Table 7.7: Activity data for Approach C (in energy units)

Parameter	Activity data (in energy units)	Units
$F_{i,j,y}$	Total fuel energy *i* (from gasoline / diesel / electricity) used per mode *j* of passenger transport (road / 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 PKMs travelled per mode *j* of passenger transport (road / rail) in year y Example: $PKM_{diesel,rail,\ 2020}$: Total PKMs travelled in rail passenger transport with diesel fuel in the year 2020.	TJ

[29] Renewable energy directive from the European Commission, published in 2009. The directive is currently being revised. Available at: https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive.

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 in order 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. If a different basis is used, the values should be converted prior to applying the emission factor, for example using the method provided by the IPCC.[30]

The estimation of the bottom-up travel activity data and the calculation of fuel energy used ($F_{x,i,y}$) differs 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

In order to estimate the activity data for road passenger transport in mass units (TJ) as depicted 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*, 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; $PKM_{i,j,y}$) 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 ($FC_{i,j,y}$) with **conversion factors** (e.g., NCV, density) in order to estimate the total fuel energy used (TJ; $F_{i,j,y}$) for each fuel type *i*, each passenger transport mode *j* in the respective year *y*.

Two outputs are obtained from the 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 in order 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 for 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.[31]

Table 7.8: Overview of bottom-up travel activity parameters (sources are in order of priority)

Parameter	Description	Unit	Sources
$d_{i,j,y}$ 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)

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

[31] For further information about parameter estimation, refer to UNFCCC 2014. Available at: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-18-v1.pdf.

			***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). Else global default value: 2 persons, including the driver (UNFCCC 2014) ***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). Else global default value: 40% of total capacity (UNFCCC 2014)[32]

[32] 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.

***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*).	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). Else, global default value for gasoline consumption of gasoline cars: 10 litres per 100 km (assumption by the authors of this methodology, based on HBEFA[33]) ***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). Else, global default value for diesel consumption of diesel buses: 50 litres per 100 km (assumption by the authors of this methodology, based on HBEFA[33])

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 gasoline and diesel use in car and bus passenger transport for Approach C

$$Total\ fuel\ consumption\ \boldsymbol{FC_{i,j,y}}\ in\ volume\ units\ (litres)$$
$$= \boldsymbol{d_{i,j,y}}\ (in\ VKT)\ x\ \boldsymbol{sfc_{i,j,y}}\ (in\ litre\ per\ VKT)$$

Since the fuel consumption is expressed in volume units (i.e., in 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, apply national values 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.

[33] HBEFA 2014.

Table 7.9: Conversion factors for the estimation of total fuel energy used (Fx,i,y) for passenger cars and buses for Approach C

Conversion factor	Description	Units	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 (Directive 1998/69/EC)[34]. Gasoline: 720 kg/m³ at 15°C (NOAA).[35]
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 (both IPCC 2006, Vol. 2 Ch. 1 Table 1.2)

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 TJ fuel energy use in car and bus passenger transport for Approach C

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

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. In order to estimate the activity data for rail passenger transport in mass units (TJ) as depicted 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 (without any bottom-up travel activity parameters).
3. Multiply the activity data in volume units ($FC_{i,rail,y}$) with **conversion factors** (e.g., NCV, density, energy conversion units) in order 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 the three steps outlined above. 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 in order to estimate mode shifts

[34] DieselNet. Available at: https://www.dieselnet.com/standards/eu/fuel_reference.php.

[35] NOAA. Available at: https://cameochemicals.noaa.gov/chemical/11498.

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.

Table 7.10: Overview of activity data parameters (sources are in order of priority)

Parameter	Description	Units	Sources
$FC_{i, rail, y}$ 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) $FC_{electricity, rail,y}$: electric 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, PKMs are available separately for diesel and electricity travel. Else, estimate total PKMs travelled in rail passenger transport (in respective year *y*).	PKM	$PKM_{rail, y}$: PKMs 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)

As in Step 2a, fuel consumption of diesel is expressed in volume units (i.e., in 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

$$\boldsymbol{F_{diesel,rail,y}}\ in\ energy\ units\ (TJ)\ =\ \boldsymbol{FC_{diesel,rail,y}}\ in\ volume\ units\ (litre)\ x\ \boldsymbol{\rho_i}\ x\ \boldsymbol{NCV_i}\ \div\ \mathbf{10^9}$$

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 TJ electricity use in rail passenger transport for Approach C

$$\boldsymbol{F_{electricity,rail,y}}\ in\ energy\ units\ (TJ)\ =\ \boldsymbol{FC_{electricity,rail,y}}\ in\ MWh\ x\ \mathbf{0.0036}$$

More detailed activity data collection can improve the accuracy and uncertainty of these results. See the *Reference Document on Measurement, Reporting and Verification in the Transport Sector* for more information on how to improve activity data collection.

Step 3: Compile emission factors

The emission factors (EF_i) represent the amount of CO_2 emissions expected to result from a) combusting a unit of fuel (e.g., gasoline, diesel) based on the total carbon content of the fuel and b) 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 methane (CH_4) and nitrous oxide (N_2O) for simplification.

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.

Table 7.11: Emission factor parameters for Approach C

Parameter	Description	Units	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 and/or fuel importers, based on their measurements) • Global default values. Gasoline: 69,300 $kgCO_2/TJ$, Diesel: 74,100 kgCO2/TJ (both IPCC 2006, Vol. 2 Ch. 3 Table 3.2.1)
EF_{diesel}	Emission factor for diesel fuel	tCO_2/TJ	
$EF_{electricity}$	Emission factor for electricity	$kgCO_2/TJ$	In order of priority: • National energy or environmental statistics (electricity mix) • National fuel providers; (e.g., refineries and/or fuel importers, based on their measurements) • Supra-regional default value (e.g., for continent). Else global default value: mainly conventional / fossil electricity production: 110,000 $kgCO_2/TJ$; at least 50% renewable share: 220,000 $kgCO_2/TJ$ (assumption by the authors of this methodology, based on UNFCCC 2014)

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 with 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

$$\boldsymbol{BE_{i,j,y}}\ in\ CO_2\ emissions\ (t\ CO_2) = \boldsymbol{FC_{i,j,y}}\ in\ energy\ units\ (TJ)\ x\ \boldsymbol{EF_i}\ (t\ CO_2\ per\ TJ)$$

Step 5: Estimate passenger kilometres

For **road transport** (gasoline cars and diesel buses[36]), the estimation can be conducted as shown in Equation 7.10 (for parameters, see Step 2a):

Equation 7.10: Estimation of PKMs for car and bus passenger transport for Approach C

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

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

For **rail transport**, PKMs are ideally estimated for both fuel energy types (diesel and electricity) separately (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 PKMs (for both diesel- and electric-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[37]. They can be differentiated for the two fuel types as follows:

Equation 7.11: Estimation of PKMs for diesel and electric rail transport for Approach C

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

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

Step 6: Calculate ratio of total emissions per mode versus PKMs

The total base year emissions can now be divided by the PKMs:

Equation 7.12: Estimation of total base year emissions per PKM (PKM) for Approach C

$$\boldsymbol{BEpkm_{i,j,y}}\ in\ CO_2\ emissions\ (kg\ CO_2)\ per\ passenger\ kilometre = \boldsymbol{BE_{i,j,y}}\ (kg\ CO_2)\ \div\ \boldsymbol{PKM_{i,j,y}}$$

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.

[36] As a simplification, the methodology is restricted to gasoline cars and diesel buses for Approach C (assuming that most of the passenger LDV transport is powered with gasoline, whereas most of the 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, or LPG) by using analogous equations with different input data (i.e. travel activity data, emission factors and elasticity values).

[37] Assumption: 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 document based on expert judgment.

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

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 be targeted at 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, the Ministry plans to assess changes in travel demand for the passenger transport modes directly and indirectly affected by the fuel levy.

The Ministry staff follows *Step 1. Align geographic aggregation* and determines that the data does not align with the new levy that will be applied nationwide. They decide to focus the GHG impact assessment only 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 estimates the total fuel energy used for **road passenger transport** (cars and buses; step 2a). They obtain the data on distance travelled 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 assumes that the buses have 40 seats on average. The average load factor equals 40% x 40 seats = 16 taken seats per VKT.

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

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

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

$FC_{gasoline,car,y}$ = 10,900,000,000 VKT x 0.1 litre per VKT = 1,090 million litres of gasoline *(Equation 7.5)*

$FC_{diesel,bus,y}$ = 980,000,000 VKT x 0.5 litre per VKT = 490 million litres of diesel *(Equation 7.5)*

For the conversion of fuel consumption in volume units to energy units, the Ministry staff uses the default density and NCV values as depicted in

Table 7.9:

$F_{gasoline,car,y}$ = 1,090,000,000 L x 720 kg/m3 x 44.3 TJ/Gg ÷ 10^9 = 34,767 TJ *(Equation 7.6)*

$F_{diesel,bus,y}$ = 490,000,000 L x 835 kg/m3 x 43.0 TJ/Gg ÷ 10^9 = 17,593 TJ *(Equation 7.6)*

Second, the Ministry staff estimates 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 million litres of diesel

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

The Ministry staff uses the default density and NCV values in order to convert the fuel consumption in volume unit to as depicted in

Table 7.9:

$F_{diesel,rail,y}$ = 300,000,000 L x 835 kg/m3 x 43.0 TJ/Gg ÷ 10^9 = 10,772 TJ *(Equation 7.7)*

$F_{electricity,rail,y}$ = 440,000 MWh x 0.0036 = 1,584 TJ *(Equation 7.8)*

Under *Step 3. Compile emission factors,* the Ministry staff chooses 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

Next, the Ministry staff determines the base year emissions by applying *Step 4. Calculate base year emissions for the selected year***:**

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

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

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

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

The Ministry staff follows *Step 5. Estimate PKMs* and estimates PKMs (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 x 2 persons = 21,800 million PKM *(Equation 7.10)*

$PKM_{diesel,bus,y}$ = 980,000,000 VKT x 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 (cumulated):

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

Starting from this cumulated value, the Ministry staff calculates the share of rail PKM with diesel and electricity:

$PKM_{diesel,rail,\ y}$ =

18,000 million PKM x ((10,772 TJ x 0.3) ÷ ((10,772 TJ x 0.3) + (1,584 TJ x 0.9))) = 12,490 million PKM *(Equation 7.11)*

$PKM_{electricity,rail,\ y}$ =

18,000 million PKM x ((1,772 TJ x 0.9) ÷ ((10,772 TJ x 0.3) + (1,584 TJ x 0.9))) = 5,510 million PKM *(Equation 7.11)*

The next step is *Step 6. Calculate ratio of total emissions vs. PKMs.* This calculation allows the Ministry staff to compare the different modes on their emission efficiency.

$BEPKM_{gasoline,car,y}$ = 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[38]

Thus, the result shows that there are approximately 4.86 Mt CO_2 annual emissions in the base year with all the modes (passenger gasoline car, diesel bus, diesel train and electric train).

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, and in particular the principle of accuracy. The assessments done using Approach C produce highly uncertain results for fuel use in passenger transport due to the following limitations:

- Uncertainties in parameter estimations are major (e.g., distance travelled) 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)

7.4 Develop a projection of baseline emissions

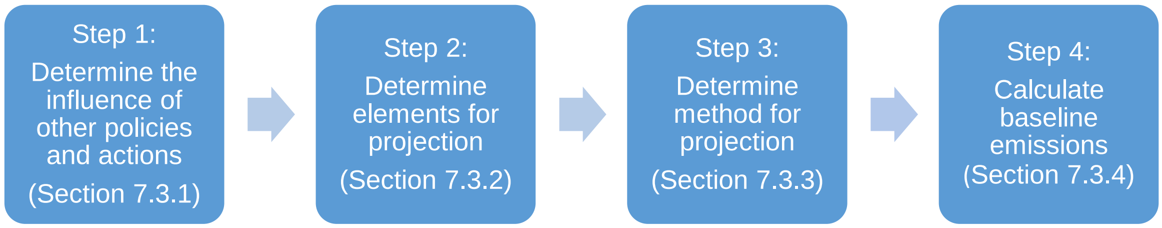
It is a *key recommendation* to develop a projection of baseline emissions for each year of the assessment period. It is necessary for most calculation parameters identified in Sections 7.1 and 7.2 to be projected into the future. By projecting the base year emissions, users can determine baseline emissions for a time series. Figure 7.7 provides an overview of steps for projecting baseline scenarios. These steps are addressed in Section 7.3.

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

[38] 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), the $BEPKM_{electricity,rail,y}$ would be approximately 32 gCO_2/PKM.

is recommended to align the timeframe used for the emissions projections of transport pricing policies with the timeframe 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).

Figure 7.7: Overview of steps for projecting baseline emissions



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

This step is comprised of two sub-steps: Determining the influencing policies and actions, followed by determining the direction and significance of effects.

Step 1a: Determine influencing policies and actions

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

Users should assess the influence of policies and actions (other than the one being assessed) on transport sector developments when projecting the baseline scenario. Some policies and actions 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 and actions together with the pricing policy as a package. In such cases, their impact would not be considered here in determining the baseline. In all other cases, their impact should be part of the baseline.

Users that are assessing the sustainable development, transformational or other GHG impacts of the policy should use the same underlying assumptions about macroeconomic conditions, demographics and other non-policy drivers. For example, if GDP is a macro-economic condition needed for assessing both the job impacts and economic developments 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 and actions, but also by other factors. In particular, technology innovation can be a critical factor influencing baseline developments. Here it is important to consider not only the most obvious policies and actions, but also to consider policies outside the transport sector. A few examples are provided in Table 7.12.

Table 7.12 Examples of policies and actions influencing transport sector developments

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

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 and actions should be. The main question related to the effect of other policies and actions is whether their influence on expected developments mainly provides a continuation of past trends or constitutes a shift from previous trends. If the general assessment is that these policies and actions impact the trend, the next question is in which direction, how much (magnitude) and 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 as 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.

Table 7.13 Assessing the relative magnitude of effects

Relative magnitude of impacts	Description	Approximate relative magnitude (rule of thumb)
Major	The policy or action 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 or action 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 effect 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.

Example: If car ownership per capita has increased by 2% per year in recent years, the question is whether policies or actions 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, as 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 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 percent points to 70.7% annual growth would be considered minor (a relative magnitude of 1%), while a 15% change in relative magnitude to 80.5% annual growth would be considered major.

Different policies and actions may influence the same parameters within the transport sector. They can be reinforcing, overlapping or independent. The relative magnitude of effects should be determined for each policy and action separately and should identify those parameters that are most likely affected together with the estimated relative magnitude of the effect.

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 developments 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.[39]

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.

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
Approach A and B					
Fuel use	Yes	Yes	Major	Moderate	
Emission factors per fuel	No Constant values[40]	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

For Approaches A and B, fuel use is influenced by population and economic growth, while emissions 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

[39] Secondary factors can be directly influenced by primary factors (e.g., 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).

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

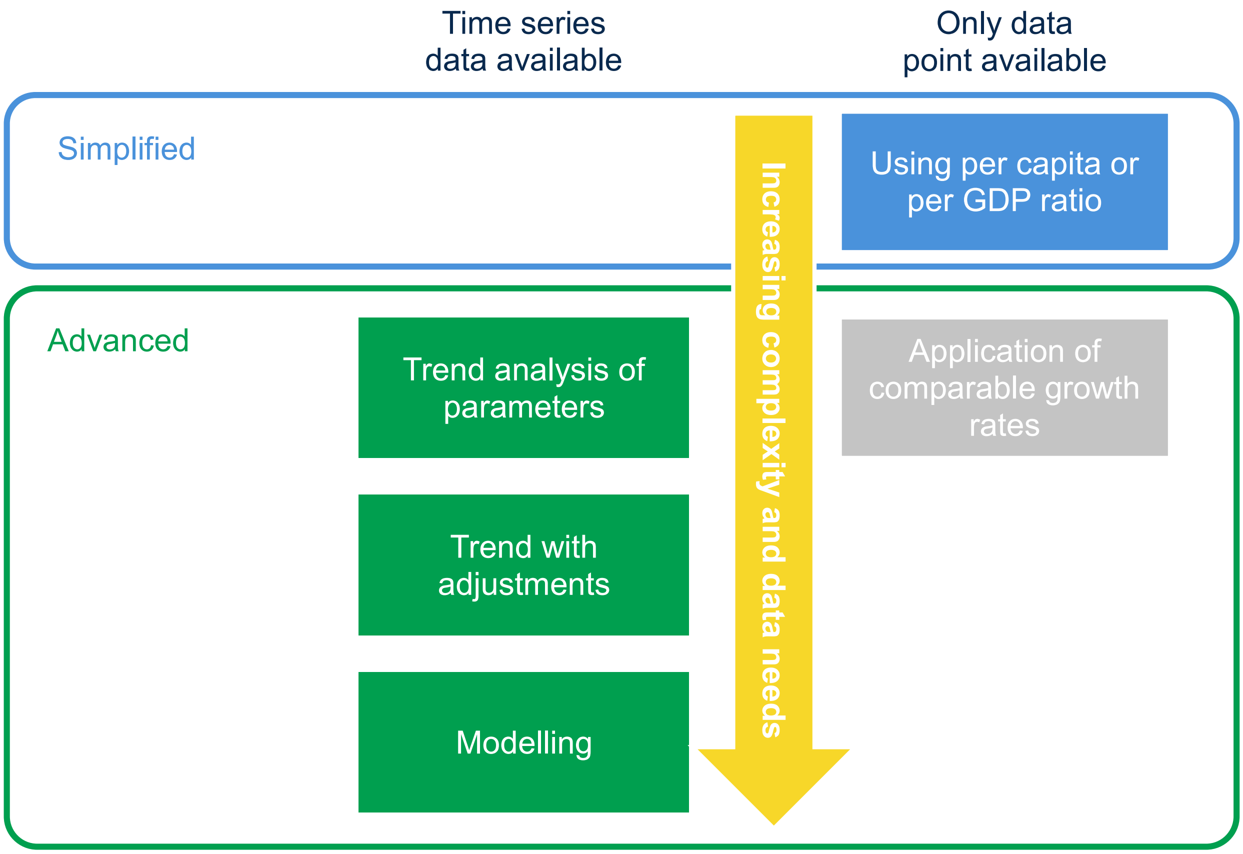
number of trips, distance travelled and fleet composition, thus there is a strong influence of population and/or GDP. Users should make projections based on the per capita or per GDP ratios of parameters to allow for meaningful projections.

7.4.3 Step 3: Determine method for projection

There are different methods available to project individual parameters and overall emissions. They vary in the 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, use statistical methods to determine trends. These trends can also be adjusted to reflect the analysis of the expected influence of 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, it may be more robust to use a multi-year average. 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 on 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 methods set out 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 the 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: Simple approach to projecting parameters using population projections

Box 7.4 provides possible sources for projections of population and GDP, while Box 7.5 provides an example illustrating the simplified method to 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.

Box 7.4: Sources for population and GDP projections

Projections for population and GDP are important elements in the determination of 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:

Population

- National statistics offices or similar agencies normally provide detailed country-level projections

- The UN Department of Economic and Social Affairs Population Division regularly publishes the *World Population Prospects.* Available at: https://esa.un.org/unpd/wpp/
- World Bank population estimates and projections. Available at: http://datatopics.worldbank.org/hnp/popestimates

GDP

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

1 *Box 7.5: Example of simplified method for projecting scenarios for Approach A*

A government plans to implement a national fuel levy on gasoline and diesel. The Ministry has already estimated the baseline emissions for the current year y (according to Section 7.2.1), and as the next step, they plan to project the base year result to the years between y+1 and y+5.

The Ministry staff starts with *Step 1: Determine elements for projection*. They decide to use the simplified method to project scenarios due to low data availability. Therefore, they keep the emission factors for fuels constant and only apply a projection to the fuel use.

In *Step 2: Determine method for projection*, the Ministry staff chooses 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 executes the calculations in *Step 3: 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% gasoline and 50% 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 equals:

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

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

The Ministry staff assumes 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 with the projected population numbers:

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

From this point, the Ministry staff calculates baseline emissions (BEi,y) by multiplying with the respective emission factor and by summing up emissions from gasoline and diesel combustion.

	Unit	Year y (historic)	Year y+1 (proj.)	Year y+2 (proj.)	Year y+3 (proj.)	Year y+4 (proj.)	Year y+5 (proj.)
Population (in millions)	Millions	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

Option 2: Advanced methods for projecting scenarios

Application of comparable growth rates

Assuming constant absolute values is in most cases an over-simplification of expected real developments. Using the per capita ratio or intensities is already a means to address this, but still falls short of real world developments, particularly since it is more than one factor that 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.

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

$$Fuel\ use\ per\ capita\ in\ year\ 2$$
$$= fuel\ use\ per\ capita\ in\ historic\ data\ year\ x\ (1 + growth\ rate)$$

$$Fuel\ use\ per\ capita\ in\ year\ 3 = fuel\ use\ per\ capita\ in\ year\ 2\ x\ (1 + growth\ rate)$$

Using the example in figure Y and applying a growth rate of 3%, this would result in the following values:

$$Fuel\ use\ per\ capita\ in\ year\ 2 = 0.0001\ TJ\ per\ capita\ x\ (1 + 0.3) =$$
$$0.000206\ TJ\ per\ capita$$

$$Fuel\ use\ per\ capita\ in\ year\ 3 = \ 0.000206\ TJ\ per\ capita\ x\ (1 + 0.3)$$
$$= 0.000206\ TJ\ per\ capita$$

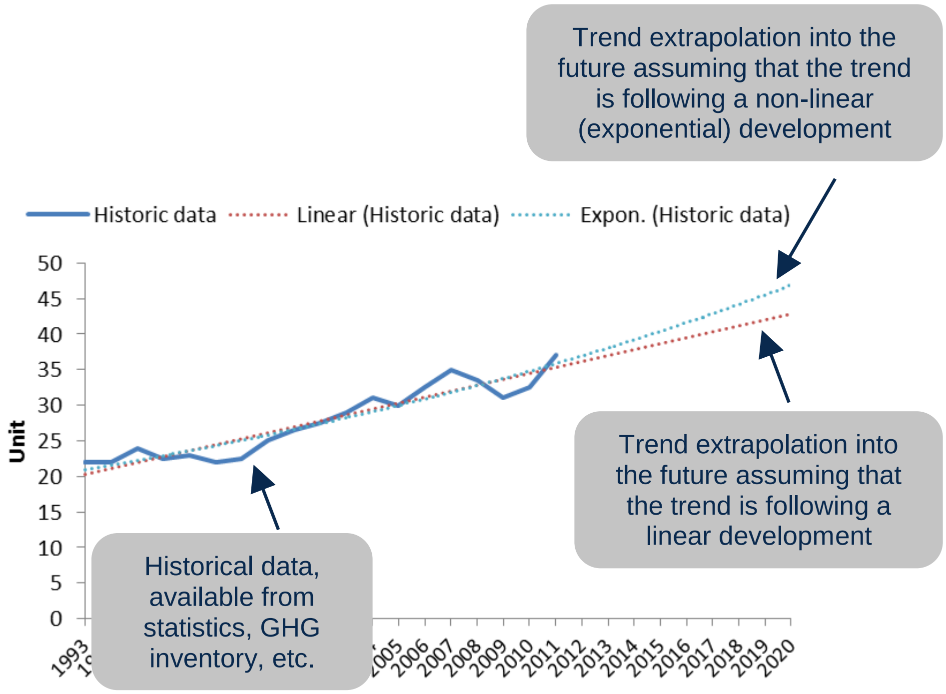
Trend analysis

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. As such, it 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 historic developments (trend) into the future in the form of a linear increase or decrease of parameters. This technique is often used in the extrapolation of historic efficiency development in vehicle efficiency (also called autonomous technology development). Constant growth rates lead to linear trends.
- **Non-linear trends**: Non-linear developments are usually captured by 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 period.
  - 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.

Figure 7.10: Projecting parameters using linear and non-linear trends



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

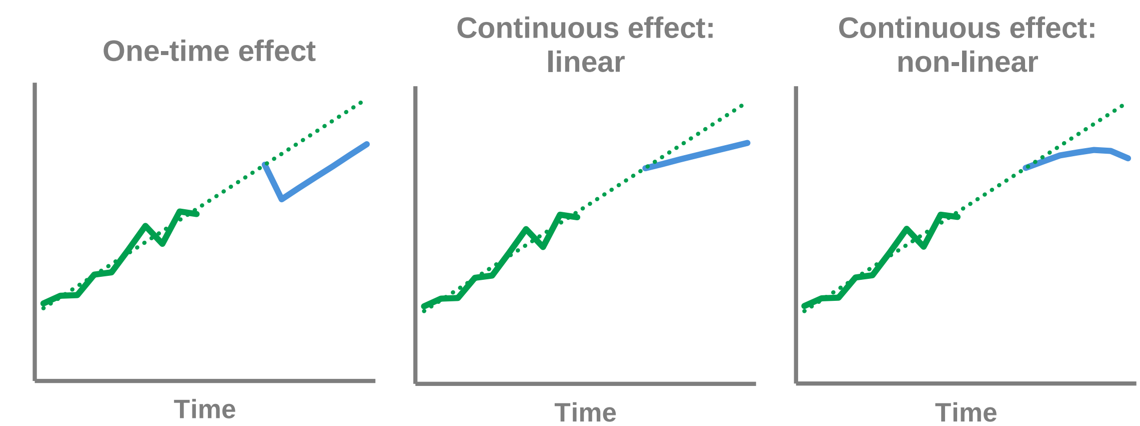
- **Available number of data points**: Although two or three data points can be seen to represent a time series, they do not allow a meaningful trend analysis. In principle, the more data points the better. With older data the consistency with newer data needs to be ensured, as data collection methods, definitions or scope may have changed over time.
- **Fluctuations in the time series**: Most parameters do not develop in a clear curve. Values change from year to year based on a wide range of influencing factors. The larger and more unpredictable these fluctuations are, the less a trend will represent likely developments. Population, for example normally has a relatively uniform development with very limited fluctuations. GDP on the other hand, shows frequent and strong fluctuations that make the determination of a trend and the projection of future GDP development challenging.
- **Expected changes in fundamental drivers**: As discussed above, policies and actions can influence the underlying drivers of individual parameters. Additionally, these can 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. While there is little we can do to capture natural and man-made catastrophes in projections, the next section discusses how to factor in some of the developments we can already foresee.

Trend with adjustments

To add another layer of analysis to the trend, the influence of policies and actions 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 which have individual dates for coming into operation. The starting point can also be the start point of the assessment, if policies or actions are already in place, but are not yet expected to be represented in the observed trend.
2. **Translate qualitative assessment into quantitative effect:** the main question is whether the effect is:
    - A one-time effect: it changes the value of the trend for the year where it occurs and then continues the trend from that new value
    - A continuous effect: effects keep influencing the parameter and lead to a complete deviation from the trend. This deviation can, as the trend itself, be linear or non-linear. The application of a learning curve, for example to reflect autonomous technology improvement, would be a classical example for a continuous, non-linear effect. The value for change should be determined based on expert judgement and, where available, experiences from other countries, regions or cities.
3. **Apply to trend:** Once the magnitude and type of the effect 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:

- *A Toolkit for Preparation of Low Carbon Mobility Plan.* UNEP 2016. Provides a detailed description of how to model transport demand based on travel characteristics. Available at: http://www.uncclearn.org/sites/default/files/inventory/a_toolkit_for_lcmp.pdf

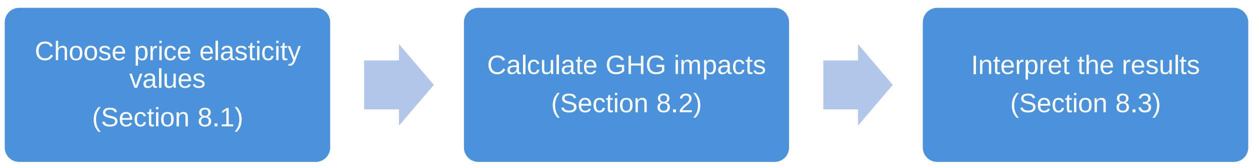
- Cube. Software for modelling and simulation of traffic and land use. Available at: http://www.citilabs.com/software/cube/
- *Energy and Emissions Reduction Policy Analysis Tool*. An integrated, state-level modelling system designed specifically to evaluate strategies for reducing transportation energy consumption and GHG emissions. Available at: https://www.planning.dot.gov/FHWA_tool/default.aspx
- *Motor Vehicle Emission Simulator (MOVES.* Estimates emissions for mobile sources at the national, country and project level. Available at: https://www.epa.gov/moves
- *TransCAD*. Provides GIS-based travel demand modelling. Available at: http://www.caliper.com/tctraveldemand.htm

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

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.

Figure 8.1: Overview of steps



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
- Carry out a careful interpretation of results, including an assessment of 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 to 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.

The own-price elasticity is the percentage change of a good’s demand divided by the percentage change of that good’s price. Own-price elasticities quantify how fuel demand changes when fuel prices rise, while cross-price elasticities quantify how the demand for other transport modes change when fuel prices rise (i.e., mode shift).

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 of a good’s demand divided by the percentage change of that good’s price. 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 of a good’s demand divided by the percentage change of a substitute good’s price. Box 8.1 provides an example calculation for both own-price elasticity and cross-price elasticity.

Box 8.1: Examples of own-price elasticity and cross-price elasticity[41]

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 fuelled vehicles
- Increased switching to different transport modes

The net impact of a fuel price change is the reduced fuel demand and subsequent emissions reductions from transport fuel use. However, a fraction of this reduction will be compensated 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 is generally collected using empirical methods. Empirically collected elasticity data from different sources can be analyzed 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 analyze 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 like 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.[42] Long-run elasticity values are elasticity values from static models or long-run elasticity

[41] 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 percent change of the demand when the price changes by one percent. (i.e., this value needs to be multiplied with the actual percent change of the price in order to determine the actual percent change of demand due to the price change determined by the pricing policy).

[42] For example, a pricing policy is perceived by the public as a long-run effect on the price (the policy is considered to be persistent), which 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.

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, Dahl (2012) found that more recent literature tends to interpret static elasticity estimates as long-run.

Dahl (2012) analyzed over 200 references on fuel price elasticities. They form the basis for the default elasticity values presented in Sections 8.1.2, 8.1.3 and 8.1.4. These values can be used for estimating 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 ahead to Section 8.2.

It is very important to be aware that price elasticity values depend on the actual price change (i.e., the price elasticity for gasoline will not be the same for a price increase of 1% as it is for a price increase of 500%). In this methodology, the default elasticity values are based on empirical studies completed within the last five decades. Hence, these elasticities 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 in order 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 is available. Approach B should be applied in the case 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 level. Fuel price elasticities change only marginally over time and can be revised for different years using the respective development of consumer price index (CPI) and 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: Default fuel mix price elasticity values (εfuel mix) for Approach A (national level)

Fuel mix price (2016 US ¢ per litre	Income per capita (2016 USD/population)[43]		
	≤ 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.

Table 8.1 shows prices and incomes per capita in US dollars for the year 2016. For every new assessment, the ranges of prices (e.g., fuel mix price ≤ 30) 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 requirement:
   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.[44]
   Calculation:
   a. Fuel price from Step 1a ÷ $\text{PPP}_{\text{conversion factor for the year of assessment}}$
   b. Per capita income from Step 1b ÷ $\text{PPP}_{\text{conversion factor for the year of assessment}}$

   Results:
   a. Fuel price (annual average) in USD for the assessment year, adjusted to PPP
   b. Local per capita income (annual average) in USD for the assessment year, adjusted to PPP
3. Adjust the ranges of fuel price (e.g., fuel mix price ≤ 30) and income per capita (e.g., income per capita ≥ 24,000) in the tables above according to the change of the US consumer price index (CPI) between the year 2016 and the year of the assessment.[45]
   Calculation:

[43] 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. It is strongly recommended to use country-specific data if available.

[44] World Bank, PPP conversion factor, GDP (LCU per international $). Available at: http://data.worldbank.org/indicator/PA.NUS.PPP).

[45] World Bank, Consumer price index (selected country = United States). Available at: http://data.worldbank.org/indicator/FP.CPI.TOTL?locations=US).

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

b. (US CPI $_{\text{for the year of assessment}}$ ÷ US CPI $_{2016}$) x 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 apply the PPPs of the local fuel price and income per capita to the adjusted price elasticity tables in order to find the accurate default price elasticities. Box 8.2 provides an example illustrating the choice of default price elasticities for Approach A.

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 USD 13,000 per capita and an (annual mean) average fuel price of USD 0.50 per litre in the year 2016.

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

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 depicted in Table 8.2 and Table 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 consumer price index development. When applying a consumer price index 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 ¢ per litre)	Income per capita (2016 USD/population)		
	≤ 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.

Table 8.3 Default diesel price elasticity (ε_{diesel}) values for Approach B (national level)

Diesel price (2016 US ¢ per litre)	**Income per capita (2016 USD/population)**	
	≤ 18,000	**≥ 18,000**
≤ 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 of the year 2016. For every new assessment, the ranges of prices (e.g., diesel price ≥ 80) 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 requirement:
   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 purchasing power parities (PPP). Use the PPP conversion factors (LCU per international $) for the year of the assessment.[46]
   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 USD for the assessment year, adjusted to PPP
   b. Local per capita income (annual average) in USD for the assessment year, adjusted to PPP.
3. Adjust the ranges of fuel price (e.g., diesel price ≥ 80) and income per capita (e.g., income per capita ≥ 18,000) in the tables above according to the change of the US consumer price index (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}) x fuel price from tables above (e.g., diesel price ≥ 80)
   b. (US $CPI_{\text{for the year of assessment}}$ ÷ US CPI_{2016}) x per capita income from tables above (e.g., income per capita ≥ 18,000)

[46] Available at: http://data.worldbank.org/indicator/PA.NUS.PPP.

[47] Available at: http://data.worldbank.org/indicator/FP.CPI.TOTL?locations=US.

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. Now you can apply the purchasing power parities of your local fuel price and income per capita to the adjusted price elasticity tables in order to find the accurate default price elasticities.

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

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 USD 13,000 per capita and a (annual mean) fuel price of 50 US ¢ per litre in the year 2016.
>
> The default gasoline price elasticity value is $\varepsilon_{gasoline}$ = -0.24.
>
> The default diesel price elasticity value is ε_{diesel} = -0.22.

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 of 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 Approach 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.
- Gasoline price elasticities change only marginally over time and can be revised for different years using the respective consumer price index development. When applying a consumer price index 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 as own-price elasticities. That is, if the gasoline demand gets 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 with increasing income per capita. Therefore, the scaling of price elasticities described in Table 8.2 and Table 8.3 can also be used as a proxy for cross elasticities.

The own-price gasoline elasticities shown in Table 8.4 are adopted from the study by Dahl (2012). 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 seats: 40). Rail systems can include both diesel and electric powered trains, and the analyzes can include cable cars, street cars, tramways, metro, commuter rail, light rail and heavy rail.

For the estimation of those cross-price elasticities, values from the United States (APTA 2011) were used as a baseline. Starting from the baseline, the elasticities for different levels of 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 represented in Dahl (2012). See Appendix F: Method for Estimating Global Default Cross-Price Elasticities for Approach C for detailed information on the method for estimating the cross-price elasticities.

Table 8.4 Default gasoline own-price elasticity ($\varepsilon_{gasoline}$) values for Approach C (national/city level)

Gasoline price (2016 US ¢ per litre)	Income per capita (2016 USD/population)		
	≤ 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.

Table 8.5 Default gasoline cross-price elasticities ($\varepsilon_{cross,j}$) for Approach C (city level)

Gasoline price (2016 US ¢ per litre)	Income per capita (2016 USD/population)		
	< 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*: List of Default Values for Price Elasticities* for further information.

The table above reflects prices and incomes per capita in US dollars of the year 2016. For each new assessment, the ranges of prices (e.g., gasoline price ≤ 30) 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 your local currency for the year of the assessment (most recent year with available data). Data requirement:

   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 purchasing power parities (PPP). 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 USD for the assessment year, adjusted to PPP
   b. Local per capita income (annual average) in USD for the assessment year, adjusted to PPP

3. Adjust the ranges of fuel price (e.g., gasoline price ≤ 30) and income per capita (e.g., income per capita ≥ 24,000) in the tables above according to the change of the US consumer price index (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}) x fuel price from tables above (e.g., gasoline price ≤ 30)
   b. ($\text{US CPI}_{\text{for the year of assessment}}$ ÷ US CPI_{2016}) x 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 apply the PPPs of the local fuel price and income per capita to the adjusted price elasticity tables in order 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[50], they should use country-specific cross-price elasticity values. Box 8.4 provides an example for choosing default own- and cross-price elasticities for Approach C.

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 USD 13,000 per capita and an (annual mean) fuel price of USD 0.50 US per litre in the year 2016.

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

[48] Available at: http://data.worldbank.org/indicator/PA.NUS.PPP.

[49] Available at: http://data.worldbank.org/indicator/FP.CPI.TOTL?locations=US.

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

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

In order 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 the 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, socio-economic 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 reporting requirements of the transparency framework.

A comparison of the three approaches, information about uncertainties and possible interpretations of the results 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. Due to the increase in fuel prices, the fuel price elasticity is negative, indicating a decreasing demand for the 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 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 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), sums the result with 1 and then multiplies this with 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 depicted in Sections 7 and 8.1.

Table 8.6: GHG impact calculation using Approach A

Label	**Approach A**	**unit**	**Data collection/calculation**	***Example year***
A	Baseline fuel use (F_y)	TJ	Input value: from Section 7.2.1 and 7.4	*782,000*
B	Baseline emissions ($BE_{fuel\ mix,y}$)	tCO_2	Input value: from Section 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 x D) + 1) x A	*773,550*
F	Anticipated GHG emissions	tCO_2	= ((C x D) + 1) x B	*55,463,850*
G	Anticipated GHG impacts (emissions reductions)	tCO_2	= F – B	*-605,650*
H	Anticipated relative impact	%	= G ÷ B	-1.1%

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 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 calculates the anticipated fuel use, emissions and GHG impacts according to the equations in *Table 8.6*:

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

Anticipated GHG emissions = ((-0.24 x 4.5%) + 1) x 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 to the baseline scenario *(see row H of Table 8.6)*.

8.2.2 GHG impact calculation for Approach B

The following input data is needed for the GHG impact calculation using Approach B (see Sections 7 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 and 8.1, whereas rows G-M show the output results and the respective equations.

Table 8.7: GHG impact calculation using Approach B

Label	Approach B	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) x A	*344,020*
J	Anticipated diesel use	TJ	= ((G x H) + 1) x B	*340,973*
K	Anticipated gasoline emissions	tCO_2	= ((E x F) + 1) x C	*23,840,560*
L	Anticipated diesel emissions	tCO_2	= ((G x H) + 1) x D	*25,266,084*
M	Anticipated emission total	tCO_2	= K + L	*49,106,644*
N	Anticipated total GHG impact (emission reduction)	tCO_2	= M – (C + D)	*-513,877*
O	Anticipated relative impact	%	= N ÷ (C + D)	*-1.0%*

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), sums the result with 1 and then multiplies this with 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 depicted in Sections 7 and 8.1.

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 8.6)*

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 calculates the anticipated fuel use, GHG emissions and GHG impacts according to the equations in Table 8.7

Anticipated gasoline fuel use = ((-0.24 x 5%) + 1) x 348,198 TJ = 344,020 TJ (see row I, Table 8.7)

Anticipated diesel fuel use = ((-0.22 x 4%) + 1) x 344,000 TJ = 340,973 TJ (see row J)

Anticipated gasoline emissions = ((-0.24 x 5%) + 1) x 24,130,121 tCO_2 *= 23,840,560* tCO_2 *(row K)*

Anticipated diesel emissions = ((-0.22 x 4%) + 1) x 25,490,400 tCO_2 *= 25,266,084* tCO_2 *(see row L)*

Anticipated emission total = 23,840,560 tCO_2 *+ 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 to the baseline scenario (see *row O of* Table 8.7*)*.

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 to this, cross-price elasticities are positive due to the fuel price increase, 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 of 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 since it is for private road transport (or possibly even non-existent). 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 than Approaches A and B, and is therefore not directly comparable to those two approaches.

The following **input data** is required for the GHG impact calculation for Approach C (see Sections 7.2 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, whereas 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	Approach C	Unit	Data collection/calculation	*Example year*	Year y (proj.)
Passenger car (gasoline)					
A	Baseline PKMs 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	g CO_2 / PKM	Input value: from Sections 7.3 and 7.4	*111*	…

	($BEPKM_{car,gasoline,y}$)				
E	Anticipated PKMs with cars	PKM	= ((B x C) + 1) x A	*21,538,400,000*	…
F	Anticipated gasoline emissions (car)	tCO_2	= D x E ÷ 10^6	*2,390,762*	…
Passenger bus (diesel)					
G	Baseline PKMs 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 ($BEPKM_{bus,diesel,y}$)	g CO_2 / PKM	Input value: from Sections 7.3 and 7.4	*83*	…
J	Anticipated PKMs with bus	PKM	= ((H x C) + 1) x G	*15,817,750,000*	…
K	Anticipated diesel emissions (bus)	tCO_2	= I x J ÷ 10^6	*1,312,873*	…
Passenger rail (diesel and electricity)					
L	Baseline PKMs with diesel rail ($PKM_{rail,diesel,y}$)	PKM	Input value: from Sections 7.3 and 7.4	12,400,000,000	…
M	Baseline PKMs 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 ($BEPKM_{rail,diesel,y}$)	g CO_2 / PKM	Input value: from Sections 7.3 and 7.4	64	…
P	Baseline rail electricity emissions per PKM ($BEPKM_{rail,electricity,y}$)	g CO_2 / PKM	Input value: from Sections 7.3 and 7.4	63	…
Q	Anticipated PKMs with diesel rail	PKM	= ((N x C) + 1) x L	*12,548,800,000*	…
R	Anticipated PKMs with electric rail	PKM	= ((N x C) + 1) x M	*5,667,200,000*	…

S	Anticipated diesel emissions (rail)	tCO_2	= O x Q ÷ 10^6	*803,123*	…
T	Anticipated electricity emissions (rail)	tCO_2	= P x R ÷ 10^6	*357,034*	…
Overall results					
U	Reference emission total	tCO_2	= ((A x D) + (G x I) + (L x O) + (M x P)) ÷ 10^6	*4,869,300*	…
V	Anticipated emission total	tCO_2	= F + K + S + T	*4,863,792*	…
W	Anticipated total GHG impact (emission 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%*	…

The equations in the column Data collection, calculation refer to the respective labelling in the column Label. For example, the calculation of the anticipated PKMs 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), sums the result with 1 and then multiplies this with the value of row A (baseline PKMs with car in the specific year). See Box 8.7 for a full calculation example. The numbers match the examples depicted in Sections 7.2 and 8.1.

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 starts by analysing private road passenger transport and retrieves 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 this data, they calculate PKMs and emissions from private passenger cars:

Anticipated PKMs with cars =
((-0.24 x 5%) + 1) x 21,800,000,000 PKM = 21,538,400,000 PKM

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

In a second step, the Ministry staff analyzes 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 this data, they calculate PKMs and emissions from passenger buses:

Anticipated PKMs with bus = ((5% x 0.15) + 1) x 15,700,000,000 PKM = 15,817,750,000 PKM

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

In a third step, the Ministry staff analyzes 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 this data, they calculate PKMs and emissions from diesel and electric rail:

Anticipated PKMs with diesel rail = ((5% x 0.24) + 1) x 12,400,000,000 PKM = 12,548,800,000 PKM

Anticipated PKMs with electric rail = ((5% x 0.24) + 1) x 5,600,000,000 PKM = 5,667,200,000 PKM

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

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

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

Reference emission total =
((21,800 Million PKM x 111 gCO2/PKM) + (15,700 Million PKM x 83 gCO2/PKM) + 12,400 Million PKM x 64 gCO2/PKM) + (5,600 Million PKM x 63 gCO2/PKM)) = *4,869,300 tCO_2*

Anticipated emission total =
2,390,762 tCO_2 + 1,312,873 tCO_2 + 803,123 tCO_2 + 357,034 tCO_2 = 4,863,792 tCO_2

Anticipated total GHG impact = 4,863,792 tCO_2 - 4,869,300 tCO_2 = -5,508 tCO_2

Anticipated relative impact = -5,508 tCO_2 / 4,869,300 tCO_2 = -0.1%

Thus, the GHG reduction in year y equals 5,395 tCO_2 or 0.1% compared to 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%

Increased capacity requirement of rail system = 0.8%)

8.3 Interpret the results

The calculations depicted in this methodology are subject to large uncertainties. It is a *key recommendation* to carry out a careful interpretation of results, including an assessment of uncertainty and the GHG impacts of use of revenues from the policy. 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, 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% up to 100% of the single result value)
4. Undertake a plausibility check of the results:
    - Consult further literature and data sources (see Appendix B: List of Literature on Price Elasticities)
    - Compare results with similar assessments from other countries or cities (i.e., conduct 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, 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 emissions vehicles, the emissions reductions may be increased due to easier and more convenient mode shift
7. Conduct the ex-post assessment presented in Chapter 9

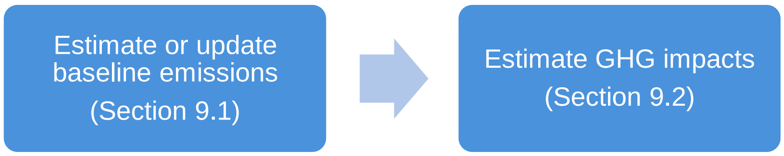
Studies on fuel price elasticities yield very broad and diverse results (see Appendix B: List of Literature on Price Elasticities for an overview). Therefore, the default values presented in this methodology have very high uncertainties, estimated by the authors of this methodology document to be between 50-100%, which may also 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 in order to avoid adverse effects, such as decreased mobility for the poorest populations. The assumptions made to choose elasticities values are important given that these values do not remain the same under continuous price increases.

9. Estimating 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 emission reductions from the ex-ante estimation. Users that are estimating ex-ante GHG impacts only can skip this chapter.

Figure 9.1: Overview of steps in the 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 10.

Where the baseline scenario was determined and baseline emissions 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.

In order to estimate the GHG impacts for a policy which 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.

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 following the method provided 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.

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 the implementation of the policy	Changes in coverage of policy impact system boundaries for GHG sources considered in Section 7
Level of pricing	The level of subsidy reduction or fee on transport fuel may change alongside the political process of the design of the policy. Or, the speed at which policies are increased may slow down	Law or regulation for the 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 allows users to use a higher level approach (i.e., B or C) or that provides a better basis for determining fuel price elasticities	National data sources	Used for updating choice in Section 4.2.2 and calculations in Sections 7 and 8.1
Baseline data	There may be more recent data on fuel consumption and other data for determining the baseline emissions (e.g., for the last year before the implementation of the policy) that can be taken into account, or more recent data on transport emission projections. In general, only activity data from before the implementation of the policy can be used for updating the baseline, as after that point the impact of the policy has already led to a deviation of emissions from the baseline scenario.	See all parameters in Section 7	Used for updating calculations in Section 7

10. Estimating GHG Impacts for Vehicle Purchase Incentives and Road Pricing

This chapter provides supplementary methods for estimating GHG impacts for vehicle purchase incentives and road pricing policies. The methodology has 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 same 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 sub fleet. 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, namely reducing vehicle travel and improving fuel economy, while most other pricing policies only reduce emissions through 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 only 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[51] as a mutually-reinforcing package (e.g., 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, road pricing and efficient parking pricing that discourages the use of fossil-fuelled vehicles and encourages the use of low-GHG emission vehicles), the description and the assessment needs to be designed accordingly, taking into account the timing and the specific type of measures (see Chapter 5 and the *Policy and Action Standard*). Note that when aggregating impacts of multiple policies there may be overlaps or interactions between the policies being aggregated (see also Chapter 4).

10.2 Purchase incentives for low-GHG vehicles

10.2.1 Overview of purchase incentives

Governments increase the fuel efficiency of the vehicle fleet and/or promote a shift to lower-carbon fuels through 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

[51] 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.

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:

- **Lower purchase taxes:** Reduce the cost of purchasing a low-GHG vehicle through 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 HKD 97,5000 (~USD 25,000). Commercial electric vehicles and electric motorcycles in Hong Kong are also eligible for tax concessions.[52] India and Malaysia also reduce 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 (~USD 4,400) rebate for new cars that achieve a threshold level of emissions was introduced in 2012.[53] In France and Portugal, rebates can be more than doubled if an eligible vehicle (e.g., a diesel car) is scrapped at the same time.[54]
- **Income tax credits:** Reduce the cost of purchasing a low-GHG vehicle or equipment such as home chargers, through 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 USD 7,500 was offered for the purchase of certain electric vehicles.
- **Lower vehicle taxes:** Reduce the annual costs of owning a low-GHG vehicle through lowering or eliminating annual registration fees or vehicle taxes. For example, China exempts electric vehicles from annual registration taxes.[55]

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.

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[52] Hong Kong Environmental Protection Department. Available at: http://www.epd.gov.hk/epd/english/environmentinhk/air/prob_solutions/promotion_ev.html.

[53] Transport Styrelsen. Available at: https://www.transportstyrelsen.se/sv/vagtrafik/Fordon/Supermiljobilspremie/.

[54] OECD/IEA 2016.

[55] Yang, Zifei, Peter Slowik, Nic Lutsey and Stephanie Searle, 2016. Available at: http://www.theicct.org/sites/default/files/publications/ICCT_IZEV-incentives-comp_201606.pdf.

Table 10.1: Factors that increase the effectiveness of purchase incentives for low-GHG vehicles

Factors	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 program. 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.[56]
Scrappage	Programme effectiveness can be improved by requiring scrappage of a high-emission vehicle to qualify for the incentive, or by providing an enhanced 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," or a combination of fee and rebate.[57]

10.2.3 Impacts of purchase incentives

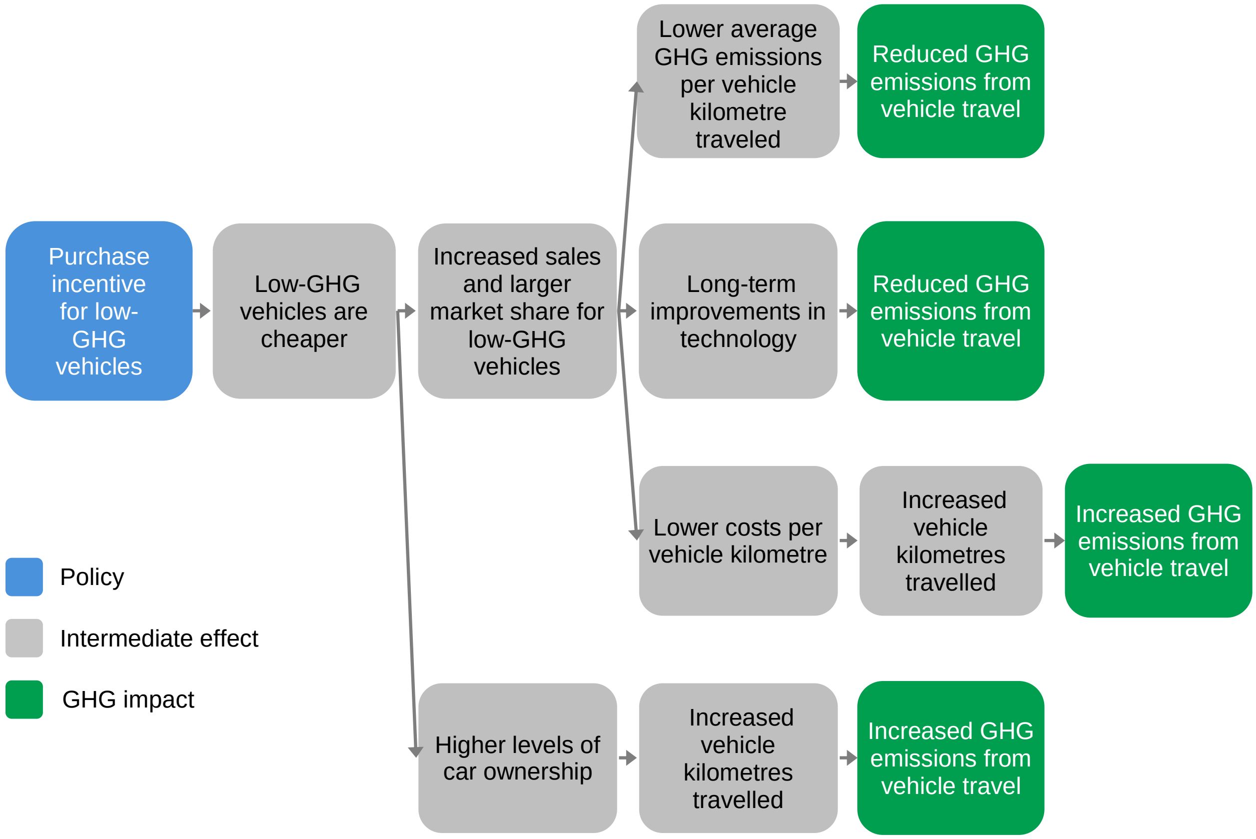
Figure 10.1 provides an example causal chain for purchase incentives for low-GHG vehicles. The most direct impact of purchase incentives on GHG emissions is the increase of the market share of electric, hybrid and other efficient vehicles, which reduces emissions per kilometre travelled either through 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 compressed natural gas or electricity cost less per unit of energy, in particular 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.

[56] For example, DeShazo, JR; Sheldon, T and Carson, R. 2016. *Designing Policy Incentives for Cleaner Technologies: Lessons from California's Plug-in Electric Vehicle Rebate Program.* Available at: http://innovation.luskin.ucla.edu/content/designing-policy-incentives-cleaner-technologies-lessons-california%E2%80%99s-plug-electric-vehicle-.

[57] For a discussion of feebates, see German, J and Meszler, D. 2010, *Best Practices for Feebate Program Design and Implementation.* Available at: http://www.theicct.org/best-practices-feebate-program-design-and-implementation.

1 *Figure 10.1: Example causal chain for purchase incentives for low-GHG vehicles*



2

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

7 The track record of purchase incentives in expanding the market share of low-GHG vehicles is mixed.
8 Some studies find no effect, while other studies find a measurable impact on GHG emissions. When
9 expressed in the cost per tCO_2e reduced, USD 100-300 is a typical range.[58] The impact of purchase
10 incentives depends on several factors summarized in Table 10.1. A general rule, however, is that
11 purchase incentives and other policies that target the fixed costs of vehicle ownership tend to have a
12 lesser impact compared to policies that target the variable costs of vehicle operation, such as fuel taxes.

13 10.2.4 Simple approach for calculating the GHG impacts of purchase incentives

14 Given the range of programme design and other factors that affect the impact of purchase incentives, this
15 methodology recommends a simplified approach based on the aggregate relationship between electric
16 vehicle (battery-electric and plug-in hybrid-electric) market share, and the cost premium (net of incentives)
17 for electric vehicles. Such a simple approach does not account for all of the impacts shown in the causal
18 chain. The assumption is that the non-quantified impacts cancel each other out, or are within the overall
19 range of uncertainty.

[58] Huse, C. and Lucinda, C. 2014. Li, S.; Linn, J and Spiller, E. 2013.

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

Follow the steps below for a simple approach to calculate the GHG impacts of purchase incentives:

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

- Use the following equation:

  Equation 10.1: Estimate average value of the rebate

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

- 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 USD 50,000, a USD 2,100 rebate is equal to 4.2%.

  For reductions in ad valorem sales taxes or excise duties, this step is straightforward. The equation 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, the number 1.2 refers to a normalized vehicle retail price (i.e. 100% + 20%).

  Example calculation: (0.2 * 50’000 USD – 0.15 * 50’000 USD) / (1.2 * 50’000 USD) * 100 = 4.2%

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

- Use the following equation:

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

  $$Market\ share\ (percentage\text{-}point\ change) = beta * average\ rebate\ value\ [from\ Step\ 1] * Market\ share\ (percentage\text{-}point\ before\ rebate)$$

  A default value for elasticity beta of 0.3 may be assumed if no country specific data is 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-km emission reductions from low-GHG vehicles

- Emission factors ($CO_2e\ km^{-1}$) for both eligible low-GHG vehicles and the existing vehicle fleet can be calculated as discussed in Chapter 7 on baseline emissions. The difference between the two represents the per-km emission savings from low-GHG vehicles.

Step 4: Calculate GHG impacts

- Use the following equation:

  Equation 10.3: Calculate GHG impacts

  $$GHG\ impact = Market\ share\ (percentage\text{-}point\ change) * annual\ new\ vehicle\ sales * per\text{-}km\ emissions\ reduction * average\ lifetime\ km\ per\ vehicle$$

Where:

- 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-km emissions reductions are calculated in Step 3
- Average annual km per vehicle is estimated using national statistics on annual vehicle km and vehicle lifespan. In their absence, a default value of 15,000 km per year can be used.[59]

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 price reduction for low-GHG vehicles) and to use the same methodology as described above. Below is an example (adapted Step 1 from above):

- The low-GHG vehicle originally costs USD 50,000 and a rebate of USD 2,100 is granted (average rebate value = 4.2%)
- The fossil-fuelled vehicle originally costs USD 25,000 and a vehicle tax of 2% on the vehicle price is introduced at the same time (absolute price increase is 0.02 * USD 25,000 = USD 500)
- The increased price of the fossil-fuelled vehicle is translated into the rebate (the total “combined rebate” equals USD 2,100 + USD 500 = USD 2,600)
- The “combined rebate value” for the low-GHG vehicle equals USD 2,600 / USD 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, then the activity data used to determine the baseline for the assessment of the rebate in 2015 already includes the impact of the fossil-fuelled vehicle tax introduced earlier.

10.2.5 Advanced approach for calculating the GHG impacts of purchase incentives

Where more data on vehicle prices, technologies and consumer demand are available, and econometric expertise is 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 simple approach presented in Section 10.1, and can also be applied to a wider range of vehicle

[59] Edenhofer et al. 2014. Available at: https://www.ipcc.ch/pdf/assessment-report/ar5/wg3/ipcc_wg3_ar5_annex-iii.pdf.

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.* Available at: http://www.theicct.org/feebate-simulation-tool.
- DeShazo, JR; Sheldon, T and Carson, R. 2016. *Designing Policy Incentives for Cleaner Technologies: Lessons from California's Plug-in Electric Vehicle Rebate Program.* Working paper. Available at: http://innovation.luskin.ucla.edu/content/designing-policy-incentives-cleaner-technologies-lessons-california%E2%80%99s-plug-electric-vehicle-.
- Jin, L; Searle, S and Lutsey, N. 2014. *Evaluation of state-level U.S. electric vehicle incentives*, International Council on Clean Transportation. Available at: http://www.theicct.org/evaluation-state-level-us-electric-vehicle-incentives
- Haultfoeuille, X; Durrmeyer, I and Février, P. 2016. *Distangling Sources of Vehicle Emissions Reduction in France: 2003-2008*. International Journal of Industrial Organization. Available at: https://www.tse-fr.eu/articles/disentangling-sources-vehicle-emissions-reduction-france-2003-2008

10.3 Road pricing

10.3.1 Overview of road pricing

National and local governments can reduce vehicle travel through charging distance-based fees to use particular roads, or 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 center 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, and drivers are charged per kilometre driven. Switzerland, for example, charges fees to heavy vehicles based on weight, emission levels and the distance driven. Annual odometer audits can also be used. Many European countries have implemented distance-based charges for heavy good vehicles.

10.3.2 Impacts of road pricing

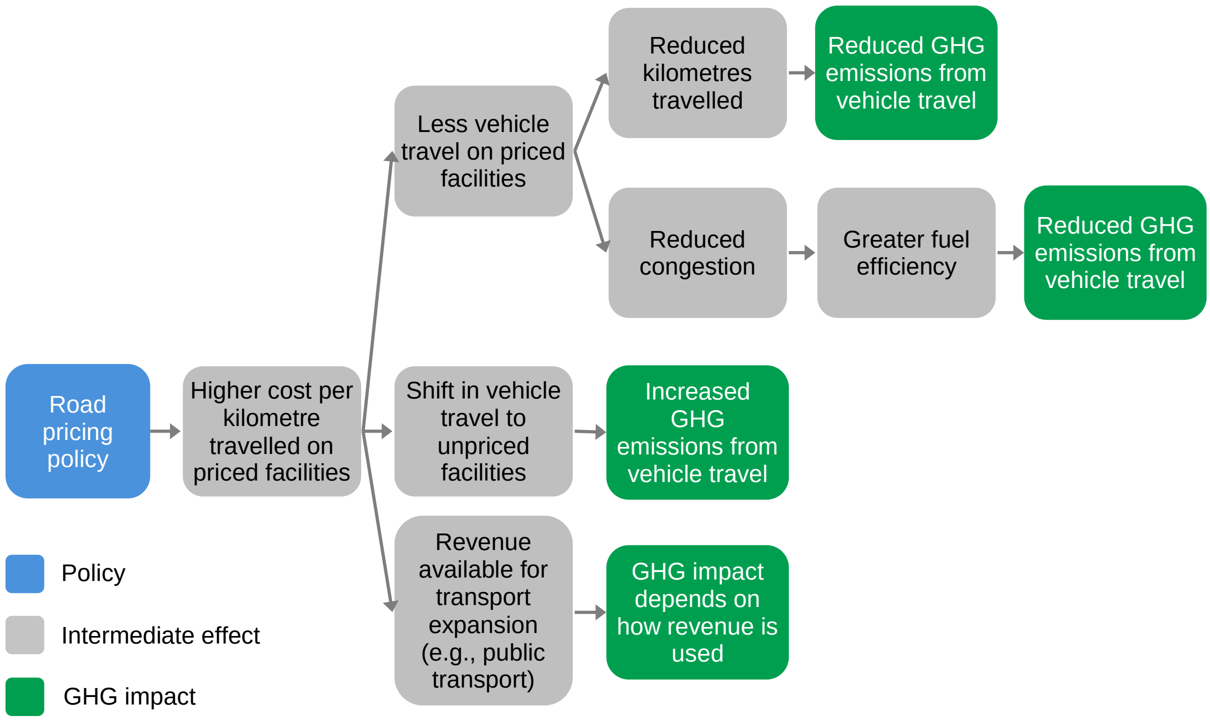
Figure 10.2 shows an example causal chain for road pricing policies. The primary impact of the increase in driving costs per kilometre travelled is reduced vehicle travel within the cordon or on the priced facility, which results in reduced emissions. The reduction in vehicle travel occurs through two 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 emission reduction impact can occur if reductions in congestion allow vehicles to operate more efficiently, through reductions in vehicle idling or operations 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, which is likely to reinforce emission 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 is likely to offset the emission savings from road pricing, and estimating the additional vehicle travel and emissions is beyond the scope of this methodology. 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 Simple approach for calculating the 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 simple approach to calculate 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^{-1}). 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, through applying a percentage reduction to the vehicle travel estimated in Step 1. A default reduction of 20% is recommended, based on the experiences in cities that have implemented cordon pricing, where reductions range from 10% to 44%.[60] This assumes that the price is in a similar range to previously implemented programmes in cities such as London (~USD 14 per day), Stockholm (up to ~USD 4 per day per entry or exit), and Singapore (up to ~USD 4.25 per entry or exit). However, project-specific estimates may be available from a travel demand model or similar source.

[60] GIZ 2015. Available at: https://www.adb.org/publications/introduction-congestion-charging-guide-practitioners-developing-cities.

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

Toll roads and distance-based charges

Step 1: Estimate vehicle travel on the priced facilities (vehicle km $year^{-1}$). For toll roads, annual traffic volume data are required. For distance-based charges, data for the subset of the vehicle fleet that is subject to the charges are required, such as the distance travelled by heavy good 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 with the method in Chapter 8). Use the equations below.

Equation 10.4: Estimate the fractional increase in driving costs

$$Fuel\ cost\ per\ km\ =\ Fuel\ price\ per\ liter\ x\ Fuel\ economy\ (liters\ per\ km)$$

$$Increase\ in\ driving\ costs$$
$$=\ Toll\ increase\ (per\ km)\ /\ (Existing\ toll\ per\ km\ +\ fuel\ cost\ per\ km)$$

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 the equation below.

Equation 10.5: Estimate change in vehicle travel

$$Change\ in\ vehicle\ travel\ (km)$$
$$=\ vehicle\ travel\ elasticity\ x\ increase\ in\ driving\ costs\ (\%)\ x\ vehicle\ travel (km)$$

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, only the second channel 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.[61] For example, if the fuel-price elasticity is -0.30, then the vehicle travel elasticity would be -0.30 x 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 the 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, mode share and congestion. For further information, refer to the following:

[61] Goodwin, P, Dargay, J and Hanly, M 2004. The mean fuel consumption elasticity is -0.64, while the vehicle km elasticity is -0.29.

- Börjesson, M; Brundell-Freij, K; and Eliasson, J. 2014. *Not invented here: Transferability of congestion charges effects*. *Transportation Research Part A: Policy and Practice* 36: 263-271.
- Eliasson, J et al. 2013. *Accuracy of congestion pricing forecasts*. Transportation Research Part A: Policy and Practice 52: 34-46.
- GIZ. 2015. *Introduction to Congestion Charging. A Guide for Practitioners in Developing Cities.* Available at: https://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 that are estimating ex-ante GHG impacts without monitoring performance can skip this chapter.

Figure 11.1: Overview of steps in the 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 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, while Table 11.2, Table 11.3 and Table 11.4 provide a summary of the relevant parameters for each approach presented in Chapters 7 and 8.

Where the results of the assessment will be used to inform the GHG accounting and reporting of progress made towards implementation and achievement of NDCs and meet the reporting requirements of the transparency framework, some of the indicators and parameters listed in the following tables to monitor progress towards achieving GHG emission reductions from the implementation of transport pricing policies can also serve as inputs to monitor progress towards achieving national GHG reduction targets, such as NDCs.

1 *Table 11.1: Key performance indicators for pricing policies*

Key performance indicators	Definition	Example key performance indicator
Inputs	Resources that go into implementing a policy	• Tax or subsidy removal
Activities and intermediate effects	Activity: Administrative activities involved in implementing the policy Intermediate effects: Changes in behaviour, technology, processes or practices	• 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
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

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

6 *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	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 • A share of 50% diesel and 50% gasoline may be assumed in the absence of any suitable national information	Measured/ estimated	Annual

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 and/or fuel importers, based on their measurements • Default values. Diesel: 74.1 tCO_2/TJ, Gasoline: 69.3 tCO_2/TJ (both IPCC 2006, Vol. 2 Ch. 3 Table 3.2.1)	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 [USD]***	National statistics	Measured	Annual
Total GHG emissions within assessment boundaries of the approach ***Total emissions [tCO_2]***	Calculated using methodology	Calculated	Annual

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/m³]***	In order of priority: • National energy statistics • Reliable international sources	Measured	Once

	• Default values. Diesel: 835 kg/m^3 at 15°C (Directive 1998/69/EC)[62]. Gasoline: 720 kg/m^3 at 15°C (NOAA)[63]		
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 (both IPCC 2006, Vol. 2 Ch. 1 Table 1.2)	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 and/or fuel importers, based on their measurements • Default values. Gasoline: 69.3 tCO_2/TJ, Diesel: 74.1 tCO_2/TJ (both IPCC 2006, Vol. 2 Ch. 3 Table 3.2.1)	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, incl. price increase through price-based policy ***Gasoline price [USD]***	National statistics	Measured	Annual
Gasoline price, including price increase through policy ***Diesel price [USD]***	National statistics	Measured	Annual
Gasoline emissions [tCO_2] Total emissions from the combustion of gasoline within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual

[62] DieselNet. Available at: https://www.dieselnet.com/standards/eu/fuel_reference.php.

[63] NOAA. Available at: https://cameochemicals.noaa.gov/chemical/11498.

Total GHG emissions from the combustion of diesel within assessment boundary of the approach ***Diesel emissions [tCO_2]***	Calculated using methodology	Calculated	Annual

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). Else global default value: 2 persons, including the driver (UNFCCC 2014) ***$l_{bus,y}$:*** 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). Else global default value: 40% of total capacity (UNFCCC 2014)[64]	Measured/ estimated/ modelled	Every 5 years

[64] 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.

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). Else, global default value for gasoline consumption of gasoline cars: 10 litres per 100 km (assumption by the authors of this methodology, based on HBEFA[65]) ***$sfc_{diesel, bus, y}$:*** 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). Else, global default value for diesel consumption of diesel buses: 50 litres per 100 km (assumption by the authors of this methodology, based on HBEFA[65])	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) ***$FC_{electricity, rail, y}$:*** electric 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
Ideally, PKMs are available separately for diesel and electricity travel. Else, estimate total PKMs travelled in rail passenger transport (in respective year y) ***$PKM_{rail, y}$ [PKM]***	***$PKM_{rail, y}$:*** PKMs 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	Measured	Every 5 years

[65] HBEFA 2014.

	• Reliable international sources • Default values. Diesel: 835 kg/m^3 at 15°C (Directive 1998/69/EC)[66]. Gasoline: 720 kg/m^3 at 15°C (NOAA)[67]		
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 (both IPCC 2006, Vol. 2 Ch. 1 Table 1.2)	Measured	Every 5 years
EF_G [tCO_2/TJ] Emission factor for gasoline fuel	In order of priority: • National energy or environmental statistics • National fuel providers, such as refineries and/or fuel importers, based on their measurements • Default values. Gasoline: 69.3 tCO_2/TJ, Diesel: 74.1 tCO_2/TJ (both IPCC 2006, Vol. 2 Ch. 3 Table 3.2.1)	Measured	Every 5 years
EF_D [tCO_2/TJ] Emission factor for diesel fuel		Measured	Every 5 years
$EF_{electricity}$ [tCO_2/TJ] Emission factor for electricity	In order of priority: • National energy or environmental statistics (electricity mix) • National fuel providers; (e.g., refineries and/or fuel importers, based on their measurements) • Supra-regional default value (e.g., for continent). Else global default value: mainly conventional / fossil electricity production: 110,000 $kgCO_2$/TJ; at least 50% renewable share: 220,000 $kgCO_2$/TJ (assumption by the authors of this methodology, based on UNFCCC 2014)	Measured	Every 5 years
$\varepsilon_{gasoline}$ [-] Gasoline price elasticity	In order of preference: • Country-specific data from empirical study or from literature • Default values provided in methodology	Measured/ estimated Uncertainty high	Once
$\varepsilon_{cross,bus}$ [-] Bus cross-price elasticity		Measured/ estimated Uncertainty high	Once
$\varepsilon_{cross,rail}$ [-] Rail cross-price elasticity		Measured/ estimated	Once

[66] DieselNet. Available at: https://www.dieselnet.com/standards/eu/fuel_reference.php.

[67] NOAA. Available at: https://cameochemicals.noaa.gov/chemical/11498.

		Uncertainty high	
Gasoline price ***[USD]*** Gasoline price, incl. price increase through policy	National statistics	Measured	Annual
Passenger kilometres with gasoline-powered passenger cars ***[PKM]*** Total passenger kilometres with passenger cars in road transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual
Passenger kilometres with diesel-powered passenger buses ***[PKM]*** Total passenger kilometres with passenger buses using diesel in road transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual
Passenger kilometres with diesel-powered passenger trains ***[PKM]*** Total passenger kilometres with passenger trains using diesel in rail transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual
Passenger kilometres with electric powered passenger trains ***[PKM]*** Total passenger kilometres with passenger trains using electricity in rail transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual
Passenger car emissions ***[tCO_2]*** Total GHG emissions from the combustion of gasoline in passenger car road transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual
Passenger bus emissions ***[tCO_2]*** Total GHG emissions from the combustion of diesel in diesel	Calculated using methodology	Calculated	Annual

bus road transport within assessment boundaries of the approach			
Diesel-powered passenger rail emissions [tCO₂] Total GHG emissions from the combustion of diesel in passenger rail transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual
Electric powered passenger rail emissions [tCO₂] Total GHG emissions from the use of electricity in passenger rail transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual
Total passenger transport emissions [tCO₂] Total GHG emissions from the road and rail passenger transport within assessment boundaries of the approach	Calculated using methodology	Calculated	Annual

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 analyzed. 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.

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 minimum, the monitoring period should include the policy implementation period, but it is also useful if the period covers monitoring of relevant activities prior to the 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 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[68]). Where two or more guidance documents 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)/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

Chapter 2: Objectives of Assessing the GHG Impacts of Pricing Policies

- The objective(s) and intended audience(s) of the assessment

Chapter 3: Steps and Assessment Principles

- Opportunities for stakeholders to participate in the assessment

Chapter 5: Describing the 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, and 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

[68] The list does not cover all chapters in this document because some chapters provide information or guidance not relevant to reporting.

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 Baseline 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

Table 12.1: Reporting on influencing policies and actions

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*

- 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 (example table provided below)

Table 12.2: Reporting on parameter assumptions and expected developments

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 EU data from EEA* *Literature review*

- Parameter values and GHG emissions 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 historic data that are available and indicating which data are historic and which were projected

Table 12.3: Reporting on parameter values and baseline emissions

	Unit	Year 1 (historic)	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 in order 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 in order to help users of the information properly interpret the results

Chapter 9: Estimating GHG Impacts Ex-Post

- Total annual and cumulative policy scenario emissions and removals 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 to estimate key parameters, including activity data, emission factors, GWP 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 in order to help users of the information properly interpret the results

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) 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*.

Appendix A: List of Default Values for Price Elasticities

This appendix provides the list of default price elasticities for a selection of countries, as estimated by Dahl (2012).

Table A.1: Default values for price elasticities

	P elasticities			P elasticities			P elasticities	
Country	ε_{gp}	ε_{dp}	**Country**	ε_{gp}	ε_{dp}	**Country**	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- P05	-0.09	-0.17	Singapore	-0.33	-0.12
Bosn&Herz	-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
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, R.	-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	Trin.&Tob.	-0.22	-0.27
Croatia	-0.32	-0.13	Maced. FYR	-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 Rep.	-0.32	-0.38	Mexico	-0.31	-0.3	UAE	-0.26	-0.13
Denmark	-0.4	-0.2	Moldova	-0.26	-0.13	UK	-0.33	-0.38
Dom. Rep.	-0.29	-0.13	Mongolia	-0.26	-0.13	USA	-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			

1 *Source:* Dahl 2012.

1 # APPENDIX B: LIST OF LITERATURE ON PRICE ELASTICITIES

2 This appendix provides a list of the most relevant literatures on price elasticities. The list of references
3 used in the methodology is provided in the References section.

4 *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
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 et al. (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 et al. (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
Bitre (2017)	*Elasticities database by the Bureau of Infrastructure, Transport and Regional Economics of the Australian Government*	Global	Several	X	X

5

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).

Reduction of fuel subsidies

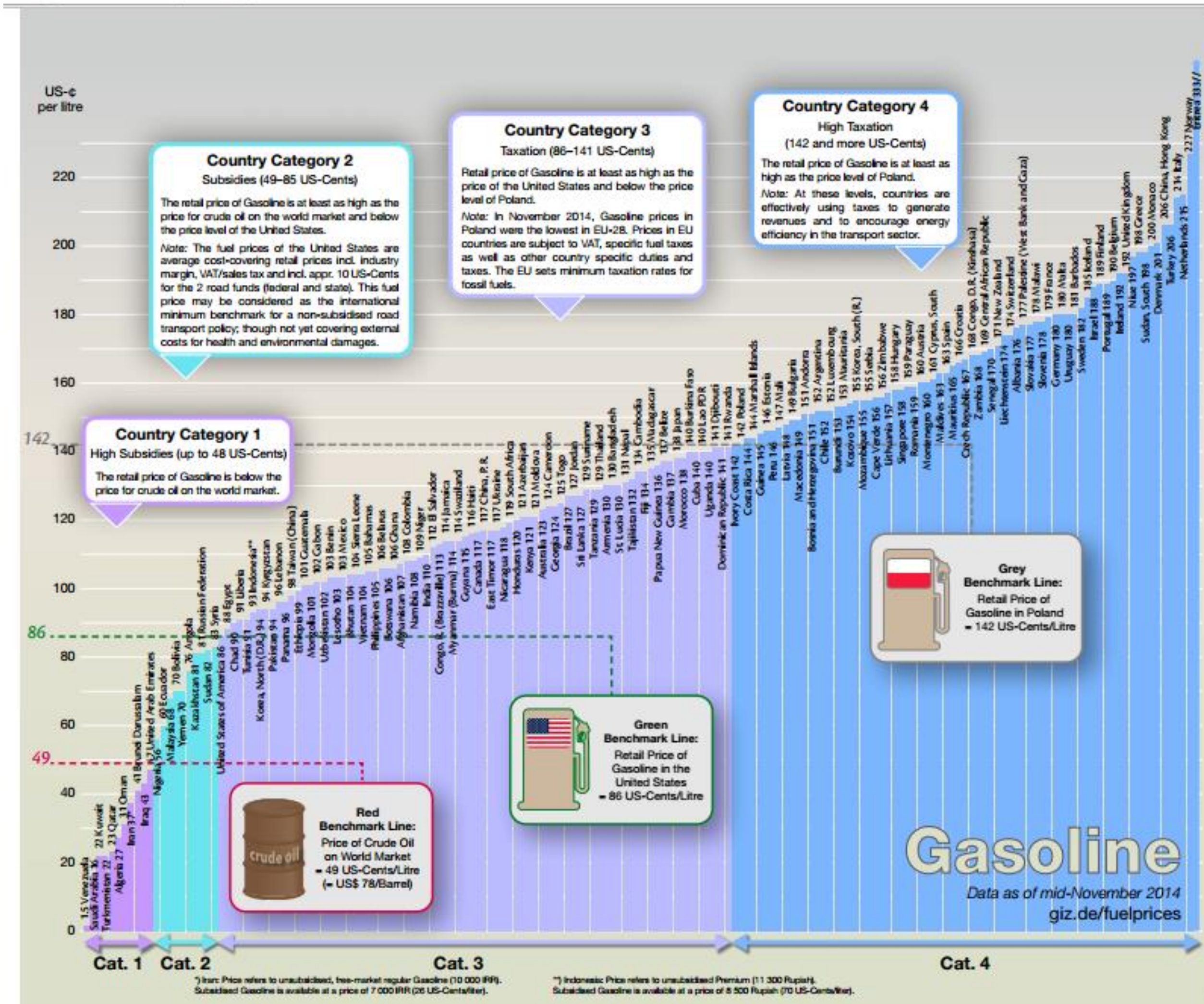
Many jurisdictions subsidize vehicle fuel, either by charging less than international market prices for domestically-produced fuel, or by subsidizing fuel through taxes.[69]. Many experts recommend reducing fuel subsidies, as a way to reduce government cost burdens and the macroeconomic costs of importing petroleum, as a way to reduce pollution emissions, and as a way to allocate public resources more equitably (since fuel subsidies benefit higher-income households more than the poor.[70] Reducing fuel subsidies can significantly increase fuel prices.

Figure C.1: International Gasoline Prices 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 USD 0.48 per litre, to cover petroleum production costs, or a moderate subsidy if it sold for USD 0.49 to 0.86 per litre, to cover petroleum and roadway production costs.

[69] ADB 2014; Metschies 2014.

[70] Coady, et al. 2010; IEA 2013; GSI 2010.

Figure C.1: International Gasoline Prices



Source: GIZ 2015.

The four categories depicted in this diagram are summarized as follows:

- **Country Category 1: High subsidies** (up to USD 0.48) – The retail price of gasoline is below the price for crude oil on the world market
- **Country Category 2: Subsidies** (USD 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 level of the United States
- **Country Category 3: Taxation** (USD 0.86 - 1.41) – The retail price of gasoline is at least as high as the price of the United States and below the price level of Poland. In November 2014, gasoline prices in Poland were the lowest in EU-28. Prices in EU countries are subject to VAT, specific fuel taxes as well as other country specific duties and taxes. The EU sets minimum taxation rates for fossil fuels.

- **Country Category 4: High Taxation** (USD 1.42 and higher) – The retail price of gasoline is at least as high as the price level of Poland. At these levels, countries are effectively using taxes to generate revenues and to encourage energy efficiency in the transport sector.

Vehicle travel and emission impacts: Fuel subsidy reductions increase fuel prices, which tends to reduce vehicle travel, encourage more efficient driving, and encourages motorists to choose more efficient and alternative fuelled vehicles.

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 they increase automatically instead of requiring special action. Some studies suggest that the high fuel taxes found in Europe, Japan and Korea are justified on economic efficiency grounds,[71] and are an efficient GHG emission reduction strategy.[72]

Vehicle travel and emission 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 encourages motorists to choose more efficient and alternative fuelled vehicles.

Carbon tax (fuel taxes based on a fuel's carbon content)

Carbon taxes are taxes based on fossil fuel carbon content, and 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 to 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 (Clarke and Prentice 2009).

Vehicle travel and emission 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 USEPA GHG Equivalencies Calculator at www.epa.gov/energy/greenhouse-gas-equivalencies-calculator). This tends to reduce vehicle travel, encourage more efficient driving, and encourages motorists to choose more fuel efficient and alternative fuelled vehicles.

[71] Clarke and Prentice 2009; Parry and Small 2004; Swiss ARE 2005; van Essen, et al. 2007.

[72] Sterner 2006.

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 (COE), and some Chinese cities are applying similar systems.[73]
- Some countries have very high import duties on vehicles, which can reduce vehicle ownership, particularly if they lack 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 electric.

Vehicle travel and emission 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 efficient vehicles. Vehicle taxes and fees that vary by fuel type, or which subsidize low-carbon fuel vehicles, can encourage motorists to choose lower-carbon fuelled vehicles.

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: Comparing road pricing objectives compares these.

Road tolls are widely used to finance highways and bridges, and some cities have implemented various types of congestion pricing.[74] Road pricing is sometimes criticized as unfair to lower-income commuters, but on most urban corridors only a small portion of motorists are low income, and road tolls are generally less regressive than other roadway funding options such as general taxes.[75]

[73] Feng and Li. 2013.

[74] Eliasson 2014; Van Amelsfort and Swedish 2015.

[75] Schweitzer and Taylor 2008.

Table C.1: Comparing 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[76])	• Reduced peak-period vehicle traffic • Is a Travel Demand Management (TDM) strategy • Revenue not dedicated to roadway projects • Requires variable rates (higher during congested periods) • Travel shifts to other modes and times considered desirable

Vehicle travel and emission impacts: Revenue-generating tolls tend to reduce vehicle travel on affected roadways. Congestion pricing tends to reduce vehicle travel under congested conditions, which by reducing congestion can provide additional energy conservation and emission 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, so, although they may significantly reduce affected vehicles' travel and emissions, their total impacts are modest.

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.[77] It may be implemented to recover parking facility costs, as a parking management strategy (to reduce parking problems), as a TDM strategy (to reduce vehicle traffic), or downtown improvement district), or for a combination of these objectives.[78] This can focus on various types of trips, such as on-street[79] or commuter parking.[80]

In most communities the majority of parking is unpriced, and 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.[81]

[76] Spears, Boarnet and Handy 2010.

[77] Shoup 2005.

[78] Weinberger, Kaehny and Rufo 2009.

[79] SF Park 2012.

[80] Rye and Ison 2005.

[81] Barter 2010; FHWA 2012.

Vehicle travel and emission impacts: Parking pricing can have various travel and emission impacts, depending on conditions:[82]

- 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, ridesharing or public transit.
- Parking pricing in a commercial 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 prices parking 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.[83] 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 USD 5-10 per day, which generally exceeds an average commute fuel costs. As a result, parking pricing can be an effective vehicle travel and emission reduction strategy.

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 charges (called *Variabilisation*) gives motorists a new opportunity to save money when they reduce their annual travel. Below are examples of distance-based pricing:

1. **Pay-as-you-drive Vehicle Insurance.** Insurance is one of the largest costs of owning a car, averaging about USD 750 per vehicle/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 distance-based vehicle insurance is to prorate existing premiums by vehicle kilometres, incorporating all existing rating factors.[84] With this system a USD 375 annual insurance premium becomes a USD 0.03 per mile fee, while a USD 1,250 annual premium becomes a USD 0.10 per mile fee. It 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 at 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

[82] Litman 2010; Vaca and Kuzmyak 2005.

[83] Hess 2001; Spears, Boarnet and Handy 2014.

[84] Ferreira and Minike; Greenberg 2013; 2010 Litman 2001.

insurance costs), and significant reductions in traffic congestion, road and parking facility costs and pollution.

2. **Distance-based Registration Fees.** This means that vehicle licensing and registration fees are prorated by vehicle kilometres, so a USD 60 annual license fee becomes a USD 0.005 per mile charge, and a USD 240 annual license fee becomes a USD 0.02 per mile charge. Similarly, other purchase and ownership fees, such as Singapore's vehicle quota charges, can be converted into variable fees.[85]

3. **Distance-based Vehicle Purchase Taxes.** Purchase taxes average about USD 1,200 per vehicle. These could be converted to distance-based taxes, which averages about USD 0.01 per mile if paid over an average vehicle lifetime, or USD 0.03 per mile if paid over the first four years of a vehicle's operating life.[86] However, this may require monitoring of distances travelled per vehicle, which may not be feasible.

4. **Distance-Based Vehicle Lease Fees**. Vehicle leases (which account for approximately 30% of new vehicle acquisitions in the U.S.) and rentals can be restructured to be more distance-based. Although most leases and rentals include additional fees for "excessive driving," this is usually set at high level and so only affects a minority of leased vehicle travel. Yet, analysis of the vehicle resale market indicates that virtually all kilometres driven increases vehicle depreciation, typically by USD 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.[87]

5. **Weight-Distance Fees**. Weight-distance fees are a distance-based road use charge that increases with vehicle weight. This would range from about USD 0.035 per mile for automobiles up to USD 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.[88]

6. **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.[89] For example, in a particular area an older vehicle that lacks current emission control equipment might pay USD 0.05 per mile, while a current vehicle might pay USD 0.02 per mile, and an Ultra-Low Emission Vehicle might pay just USD 0.01 per mile. However, this may require monitoring of distances travelled per vehicle, which may not be feasible.

Vehicle travel and emission impacts: The vehicle travel and emission impacts of distance-based pricing can vary significantly depending on the strategy and the conditions in which is it implemented. Since vehicle insurance, registration fees, purchase taxes and lease fees are relatively large in

[85] Barter 2004; Greenberg 2000.

[86] Greenberg 2000.

[87] Greenberg 2000.

[88] Haldenbilen and Ceylan 2005.

[89] Sevigny 1998.

magnitude, 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 reductions than mileage, since vehicles with the highest emission rates would be charged the highest per-kilometre fees, and so have the greatest incentive to reduce travel.

Public transit fare reforms (reduced and more convenient fares)

Public transit fare reforms can include reduced fares, free transfers, universal transit passes (for example, all students at a university or all employees at a worksite receive transit passes), and more convenient payment systems (such as passes, electronic payment cards, or mobile telephone payment systems).

Vehicle travel and emission impacts: Although most transit travel has relatively low price elasticities, some pricing reforms can have relatively large impacts on travel.[90] For example, universal transit passes can significantly increase affected travellers transit travel.

Company car tax reforms (reduce tax structures that encourage employers to subsidize employees' car travel)

A significant portion of vehicle travel is by *company cars*, 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 driven higher mileage than those motorists would choose if they purchased vehicles and fuel themselves.[91] 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[92] found that most EU countries under-tax company cars, resulting in direct revenue losses that may approach 0.5% of EU GDP (EUR 54 billion), and welfare losses from distortions of consumer choice are substantial, perhaps equal to 0.1 to 0.3% of GDP (EUR 12 billion to EUR 37 billion).

To encourage energy efficiency, in 2002 the UK implemented a new company car tax system based the tax on the level of CO_2 emissions they produce.[93] The business mileage discounts have been removed in order 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 between 300 and 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, Potter and Atchulo's 2012 review of the UK tax reform 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 the drivers of

[90] McCollom and Pratt 2004.

[91] Rivers, et al. 2005.

[92] Næss-Schmidt and Winiarczyk 2009.

[93] HMRC 2006.

low and ultra-low carbon vehicles. This change provides a financial advantage for hybrid and electric vehicles, which make them the dominant clean vehicle technology.

Vehicle travel and emission impacts:

In countries where company cars are a significant portion of new vehicles and are more energy intensive than what 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.

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 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 and school transportation), direct costs to consumers from increased motor vehicle travel, and increased external traffic costs including congestion, accidents and pollution emissions.[94] 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.[95]

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.[96] Several studies have calculated the additional fees that should be charged for sprawled, automobile-dependent development.[97]

Vehicle travel and emission impacts: Smart growth pricing reforms, which charge lower development fees and utility charges for buildings located in more compact areas, and which 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.

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[94] de Duren and Compeán 2015; Ewing and Hamidi 2014; Litman 2014.

[95] Boarnet and Handy 2010; Ewing and Cervero 2010; Mehaffy 2015.

[96] Blais 2010.

[97] Calgary 2016; SGA and RCLCO 2015; Stantec 2013.

APPENDIX D: OVERVIEW OF REVENUE IMPACTS OF PRICING POLICIES

Table D.1: Pricing policies potential revenue impacts: Pricing impacts vary depending on how revenues are used 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: Pricing policies potential revenue impacts: Pricing impacts vary depending on how revenues are used

Pricing policy	Possible revenue uses	Travel and emission impacts	Other impacts
Reduce fuel subsidies	Reducing 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 emission reductions if a portion of revenues are invested in emission reductions programmes	Varies. By reducing vehicle travel it provides traffic reduction benefits.
Increase fuel taxes	Contribute to general funds, invested in roads, or invested in 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.
Increase vehicle taxes	Contribute to general funds, invested in roads, or invested in 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	Invest 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	Invest in parking facilities, invested in other transport modes, or help finance other	If invested to improve other modes, can reduce vehicle travel and emissions.	If invested to improve other modes can significantly reduce traffic problems and

	local government services.		improve mobility for non-drivers.
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 different components that determine the transport sector's GHG emissions: ASIF stands "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: Key indicators for transport MRV using the ASIF framework 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 lifecycle assessment) • Fuel quality (e.g., sulphur content)
Bottom-up	Activity (A) and Modal Shift **(S)**	Fleet composition	• Number of vehicles by vehicle type (e.g., car, truck, motorcycle)	• By vehicle classes or engine size • By vehicle age or technology
		Distances travelled	• Vehicle kilometre by vehicle type (in VKT) • Passenger kilometre (PKM) • Tonne kilometre (TKM)	• By mode • By vehicle classes or engine size • By vehicle age or technology
		Trips	• Number of trips • Tonnes transported • Trip length	• By mode • By trip purposes (e.g., work, leisure)
		Load factor	• Occupancy (in persons/vehicle) • Load of goods vehicles (in %)	• By mode • By vehicle classes or engine size
Bottom-up	Intensity **(I)**	Fuel consumption	• Fuel consumption (in litre or kwh/km) by vehicle type	• By vehicle classes (size usually related to weight) • By vehicle age engine technology (e.g., Euro standards) • Speed and/or congestion on the road (level of service) • By load (for trucks • By gradient (for trucks) • Aerodynamic design and rolling resistance of tires

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 also Appendix C: Overview of Pricing Policies for a list of further reading). No complete and comprehensive data set of cross-price elasticities is accessible at the time. 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 (APTA 2011). The cross-price elasticities for rail had to be averaged over several (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: Choosing suitable descriptive parameters

The cross-price elasticity values assumed for the United States are not applicable globally and need to be adjusted for global applicability according to suitable descriptive parameters. Such parameters are defined in the paper by C. Dahl on gasoline and diesel own-price elasticities (Dahl 2012): (1) **fuel price** and (2) **average per capita income**. The authors assumed that those parameters could also be used to estimate cross-price elasticities.

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 income per capita on the cross-price elasticity is exactly the same as it is on the own-price elasticity, as according to Dahl. Box F.1 illustrates how this was done.

Box F.1: Example – Adjusting the US-specific cross-price elasticity value to another country

The objective is to adjust the US-specific cross-price elasticity value to another Country C. The average gasoline price and income per capita is known for both countries:

Parameters	United States	Country C
Gasoline price (USD per litre)	0.60	0.25
Income (USD 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 in correspondence to the parameters gasoline price and per capita income, Country C has an own-price elasticity that is 50% lower than equivalent value for the United States. We now assume that the same ratio also counts for cross-price elasticities. The United States has the following fuel cross-price elasticities (APTA 2011):

United States: Cross-price elasticity towards bus systems: **0.14**

United States: 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:

Country C: Cross-price elasticity towards bus transport = 0.14 x 0.5 = **0.07**

Country C: Cross-price elasticity towards rail transport = 0.223 x 0.5 = **0.11**

The example can be reproduced in Table 8.5 within Section 8.1.4. The values in grey represent the cross-price elasticities applicable for the United States (APTA 2011). The values in yellow represent the cross-price elasticities applicable 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: Default gasoline own-price elasticity ($\varepsilon_{gasoline}$) values for Approach C (national/city level)

Gasoline price (2016 USD per litre)	Income per capita (2016 USD/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

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, explaining 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 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 on 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 related 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 price signals 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 baseline emissions	• Inform assumptions on expected effects of existing and planned policies	Chapter 8 – Designing and conducting consultations
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 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 Technical Working Group:

- 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

CDM	Clean Development Mechanism
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
tCO_2e	tonnes of carbon dioxide equivalent
CNG	compressed natural gas
GHG	greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
HDV	heavy-duty vehicle
ICAT	Initiative for Climate Action Transparency
LPG	liquified petroleum gas
NCV	net calorific value
NDC	Nationally Determined Contribution
LDV	light-duty vehicle
MRV	Monitoring, Reporting and Verification
NAMA	Nationally Appropriate Mitigation Action
PKM	passenger kilometre
TKM	tonne kilometre
UNFCCC	United Nations Framework Convention on Climate Change
VKT	vehicle kilometre
WRI	World Resources Institute

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/or transformational impacts of the 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 the policy leads to impacts through a series of interlinked logical and sequential stages of cause-and-effect relationships
Cross-elasticity of demand	A policy of the responsiveness of the quantity demanded for a good to a change in the price of another good, ceteris paribus. 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 of a good's demand divided by the percentage change of 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 estimating historical GHG impacts of a policy (i.e., a backward-looing 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 (IPCC 2006)
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 vehicles (HDV)	A vehicle designed for heavy work (bus or truck) which is generally powered by a diesel engine
Impact assessment	The 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

Inputs	Resources that go into implementing the 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 the 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 vehicles (LDV)	Any motor vehicle with a gross vehicle weight rating of 10,000 pounds or 4,500 kg or less, which generally use gasoline
Monitoring period	The time over which the 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 (such as national and subnational energy efficiency standards for appliances), as well as counteracting or countervailing policies that have different or opposing goals (such as 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 of a good's demand divided by the percentage change of 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 the 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 new technologies, processes, or practices; and public or private sector financing and investment, among others

Policy scenario	A scenario that represents the events or conditions most likely to occur in the presence of the policy (or package of policies) being assessed. The policy scenario is the same as the baseline scenario except that it includes the (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 policy of the responsiveness of demand or supply of a good or service to changes in price. The price elasticity of demand policies the ratio of the proportionate change in quantity demanded to the proportionate change of 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, including 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, among others
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 the 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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