INCLUSIVE FORUM ON
CARBON MITIGATION APPROACHES
PAPERS

Greenhouse Gas Emissions Mapping Methodology for Climate Change Mitigation and Mitigation-Relevant Policy Instruments

A Methodological Note to Support GHG Mapping for the IFCMA Country Pilot Studies

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Inclusive Forum on Carbon Mitigation Approaches Papers

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The IFCMA Papers series brings together outputs from the initiative's work to take stock of different carbon mitigation approaches, map policies to the emissions they cover, and estimate their impact on greenhouse gas emissions, as well as its work on analysing methodologies for computing the carbon intensity of goods and sectors. Comments on IFCMA Papers are welcome at IFCMA@oecd.org.

Background

The Inclusive Forum on Carbon Mitigation Approaches is the OECD's flagship initiative to help optimise the global impact of emissions reduction efforts around the world through better data and information sharing, evidence-based mutual learning, and inclusive multilateral dialogue.

By taking stock of different carbon mitigation approaches, mapping policies to the emissions they cover, and estimating their comparative impact in terms of emissions reductions, the IFCMA is enhancing understanding of the effect of the full spectrum of carbon mitigation approaches deployed around the world and their combined global impact. The IFCMA is also identifying and addressing challenges related to the calculation of sector- and product-level carbon intensity metrics, relevant to the design and evaluation of mitigation policies, and to steer firms' and consumers' decisions towards lower-emission products. This work supports better international coordination to avoid the proliferation of different standards, help minimise compliance costs for business, and avoid disruptions to trade.

To advance its technical work, the IFCMA brings together delegates from the climate, tax, and structural economic policy communities from more than 55 IFCMA members and numerous countries participating as Invitees around the world.

Abstract

This document proposes a methodology to map policy instruments to their greenhouse gas (GHG) emission base. It seeks to support the efforts under the Inclusive Forum on Carbon Mitigation Approaches (IFCMA) to enhance the understanding of countries' climate change mitigation policies by providing a comprehensive and systematic stocktake of policy instruments and establishing a corresponding database. The GHG mapping methodology is designed to be inclusive, covering a broad set of policy instruments relevant for climate change mitigation and is being applied to country pilot studies under the IFCMA. It develops several key concepts and definitions and proposes a five-step approach that focuses on a policy instrument's administrative design, policy regulatory base and the legal obligations established under the regulatory framework. Finally, it presents two GHG mapping examples drawn from one of the first IFCMA pilot studies (Chile).

Keywords: climate change mitigation, climate policy, climate action, policy instruments, GHG emission coverage

JEL classification codes: Q48: Agricultural and Natural Resource Economics; Environmental and Ecological Economics / Energy / Energy: Government Policy; Q54: Agricultural and Natural Resource Economics; Environmental and Ecological Economics / Environmental Economics / Climate; Natural Disasters and Their Management; Global Warming; Q58: Agricultural and Natural Resource Economics; Environmental and Ecological Economics / Environmental Economics / Environmental Economics: Government Policy

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The work has been carried out under the supervision of Jo Tyndall and Nathalie Girouard of the OECD Environment Directorate and Manal Corwin and Kurt Van Dender of the OECD Centre for Tax Policy and Administration. Lydia Servant provided administrative support.

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Executive Summary

The Inclusive Forum on Carbon Mitigation Approaches (IFCMA) is an initiative designed to help optimise the global impact of greenhouse gas (GHG) emission reduction efforts around the world through better data and information sharing, evidence-based mutual learning and inclusive multilateral dialogue. It brings together all relevant policy perspectives from a diverse range of countries from around the world, participating on an equal footing, to take stock of and consider the effectiveness of different carbon mitigation approaches. The project is organised around two modules.

The objective of Module 1 is to carry out a comprehensive and systematic stocktake of climate change mitigation and mitigation-relevant policy instruments and map them to their GHG *emission base*. Module 2 focusses on estimating the impact of different policy instruments on GHG emission reductions. The *emission base* refers to the GHG emissions that a policy instrument covers through its regulatory structure. These emissions can be targeted as an explicit objective, in the case of climate change mitigation policy instruments (e.g. a carbon tax), or implicitly, in the case of climate change mitigation-relevant policy instruments (e.g. an excise tax).

It is important to note that while the emission base is of interest and provides valuable information on the policy instrument and its intended impact, it does not estimate the potential effectiveness of policy instruments or GHG emission reductions. This can only be ascertained through modelling techniques that can estimate the direct and indirect effects of a policy instrument in the context of the specific conditions of where the policy instrument is implemented (the objective of IFCMA Module 2).

This paper proposes a GHG mapping methodology that allows for the granular and systematic estimation of the emission bases of a wide range of policy instruments. The proposed methodology will be applied to IFCMA country pilot studies, which aim to inform methodologies to undertake the IFCMA's work across a broad set of countries. The emission base will be a key attribute in the policy stocktake conducted in Module 1.

The methodology aspires to be comprehensive in its ability to cover a broad set of policy instruments relevant for climate change mitigation. However, emissions mapping can be complex, especially when the relationship between the instrument and the emissions coverage is indirect, or when instruments have variable impacts on emissions. This note therefore recognises that it might not be possible in all cases to determine the emission base. The pilot studies will provide valuable insights into the feasibility of conducting large-scale mapping of GHG emissions.

The mapping methodology develops several key concepts and definitions and proposes a five-step approach that focuses on a policy instrument’s administrative design, regulatory base – determining what and who is regulated – and the legal obligations established under the regulatory framework. Finally, it presents two GHG mapping examples drawn from the IFCMA pilot studies.

1. Introduction

1. A growing number of countries are committed to increased mitigation efforts to achieve the greenhouse gas (GHG) emission targets established in their nationally determined contributions (NDCs). To achieve these targets, governments apply different approaches, implementing a wide variety of policy instruments (see Nachtigall et al. (2022[1])). There is increasing interest in examining these instruments both to gain a detailed understanding of how they operate and to evaluate their effectiveness. The Inclusive Forum on Carbon Mitigation Approaches (IFCMA) seeks to meet this need by carrying out a stocktake and GHG emissions mapping of policy instruments (Module 1) and estimate their effectiveness (Module 2).

2. The IFCMA aims to provide a comprehensive and systematic stocktake of policy instruments, covering all IFCMA member countries.[1] The resulting database will describe policy instruments through key attributes that capture information related to their classification, regulatory structure, and implementation design. An especially important attribute is the policy instrument's coverage of GHG emissions, which requires mapping the policy instrument to its *emission base*.

3. The primary objective of identifying the emission base is, alongside other attributes such as intensity, characterise a policy instrument by describing its scope. For example, a carbon tax that covers 10% of national emissions is substantially different from one that covers 50%, since in the latter case it applies to a broader set of emissions than the former. Therefore, the emission base provides an indicator of the "breadth" of a policy instrument with respect to the emission it covers.

4. GHG mapping can provide policymakers with insights on the coherence across instruments, revenue implications, regulatory burden and interaction among policies. GHG mapping can identify gaps in policy action and facilitate the analysis of policy interactions by highlighting where instruments cover the same emission base (overlap) and where they could be covering different segments of the emissions. GHG mapping can furthermore help to track the evolution of climate action over time.

5. It is important to underscore that GHG mapping does not estimate the effects of policy instruments on emissions. A broader emission base coverage does not necessarily result in a more effective policy for reducing emissions. The effectiveness of a policy instrument depends on various factors, including the responsiveness of the emission base to the policy instruments and potential indirect effects. Impacts will depend on a range of conditions, and estimating the effects will require modelling techniques; this is covered explicitly under Module 2 of the IFCMA.

6. Nevertheless, by identifying the specific emissions covered, mapping can also enhance modelers' ability to evaluate effectiveness (e.g. in IFCMA's Module 2). While the GHG mapping information may be too granular for the modelling, it can still serve as a valuable starting point. For example, since the mapping describes which entities and assets (and their associated emissions) are covered, it can act as a bridge between the detailed policy stocktake and the modelling work, which typically operates on a more

[1] The IFCMA membership on 20 June 2024 is Argentina; Australia; Austria; Barbados; Belgium; Bulgaria; Cameroon; Canada; Chile; Croatia; Colombia; Costa Rica; Czechia; Denmark; Estonia; European Union; Finland; France; Germany; Greece; Hungary; Iceland; Ireland; Israel; Italy; Jamaica; Japan; Kazakhstan; Latvia; Lithuania; Luxembourg; Malta; Mauritius; Mexico; Monaco; Morocco; Netherlands; New Zealand; Nigeria; Norway; Paraguay; Peru; Philippines; Poland; Portugal; Romania; Singapore; Slovakia; Slovenia; South Africa; South Korea; Spain; Sweden; Switzerland; Türkiye; United Kingdom; United States; Uruguay; Zambia.

aggregated scale (e.g. spatial, sectoral). This can aid in policy selection for modelling work, and in interpretating modelling results, by showcasing the relation between intended emissions coverage and the actual net impacts of an instrument on emissions.

7. The OECD has previously undertaken GHG emissions mapping for analysing carbon pricing instruments, such as emission trading systems, carbon taxes, fuel excise taxes and selected fossil fuel subsidies (OECD, 2022[2]). However, there is less experience with other market-based policy instruments and practically none with non-market-based policy instruments. Building on this methodology, this paper proposes a GHG mapping methodology for a wide range of policy instruments, covering both climate change mitigation policy instruments and climate change mitigation-relevant policy instruments, and both market and non-market-based instruments.[2] The methodology aims to be comprehensive but acknowledges that, in cases where instruments have complex or indirect impacts on emissions, establishing a direct and exact relationship, or a "one-to-one" mapping with specific GHG emissions may not always be feasible.

8. Emissions mapping requires a clear understanding of what and who is regulated - referred to as the *policy regulatory base* (to simplify *policy base*), the policy instrument's design, and where emission reductions are expected to materialise. While the emission base is typically directly linked to the policy base (see below), in some cases instruments may be designed to influence emissions from assets regulated outside the policy base. In this case the relationship between the instrument and the emissions coverage is indirect. For example, a subsidy on electric vehicles (EVs) and a tax on internal combustion engine (ICE) passenger cars are policy instruments with different legal obligations and policy bases, but have the same emission base, namely the set of emissions associated with the fleet and use of passenger cars. Furthermore, the emissions from the actual assets regulated are different, and may be associated, as in the case of EVs, with emissions quantified through electricity use, often referred to as scope 2 emissions.

9. There are several challenges to consider when undertaking GHG emissions mapping. First, the availability of detailed data on GHG emissions can be a hurdle. Second, the complexity of certain instruments may make mapping difficult, e.g. corporate tax incentives with a very indirect relationship to an emission base. Finally, resource constraints can also pose a challenge. For this reason, while mapping may, in theory, be possible for many instruments, it may be necessary to prioritise some instruments and sectors for practical reasons. Therefore, this methodology should be taken as a framework to be implemented as data is available and resources permit. The IFCMA pilot studies will investigate the feasibility of large-scale mapping, including where granular emissions data is unavailable.

10. The application of the mapping methodology in the IFCMA pilot studies will shed light on some of the practical challenges, while also providing insights into the utility and limitations of mapping results for policy analysis or modelling. It will also show constraints in mapping certain instruments, and it will underscore the value and challenges associated with considering indirect emissions in the mapping process.

11. This paper is structured in the following way. Section 2 proposes key definitions and introduces new concepts to establish a common understanding. Given the range of possible climate change policy instruments and their different design structures and expected impact, it is crucial to define key terms and concepts. Section 3 outlines a step-by-step approach to apply the methodology, while Section 4 discusses several examples to illustrate its implementation.

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[2] Climate change mitigation policy instruments explicitly intend to reduce GHG emissions, whereas climate change mitigation-relevant policy instruments can induce changes in emissions without necessarily having climate change mitigation as a primary goal.

2. Key concepts and definitions

12. Mapping policy instruments to their GHG emission base has so far only been applied to a limited set of policy instruments, principally carbon pricing instruments such as emission trading systems, carbon taxes, fuel excise taxes and selected fossil fuel subsidies (OECD, 2022[2]). Presently the OECD has comprehensive information on the extent of the use of carbon pricing across 72 countries representing 80% of global GHG emissions (OECD, 2022[2]).

13. However, there is less experience with other market-based policy instruments and practically none with non-market-based policy instruments. To guide the wider application of GHG emissions mapping, this paper proposes a methodology that can potentially be applied to a broad range of policy instruments, spanning climate change mitigation and mitigation-relevant instruments for both market- and non-market-based instruments. To support this wider application, this section provides definitions and concepts as a basis for the methodology presented in Section 3.

2.1. Policy instruments

14. Policy instruments are institutional tools through which governments influence, enforce, or guide behaviour with the aim of achieving specific policy goals. Most policy instruments have implications for economic agents – individuals or entities – establishing enforceable legal requirements (e.g. adhere to a standard or pay a tax) or providing legal avenues for agents to engage in or benefit from certain activities (e.g. receive a subsidy), whose compliance and enforcement are implemented through dedicated laws, regulations, or other legal frameworks.[3] Policy instruments can impact GHG emissions by influencing production and consumption choices directly, in the case of climate change mitigation policy instruments, and indirectly, in the case of climate change mitigation-relevant policy instruments. The former are explicitly designed to reduce GHG emissions, while the latter have a significant or potential mitigation effect without explicitly targeting emissions reduction as a policy goal. Both types of instruments can be mapped to their relevant emission base. Table 1 provides examples of both types of instruments.

Table 1. Examples of climate change mitigation and mitigation-relevant instruments

Instrument type	Instrument examples
Climate change mitigation instruments	Carbon taxes, emission trading systems, ban on building new coal power plants, GHG emission standard, public investment in low-emission buses
Climate change mitigation-relevant instruments	Fuel excise tax, speed limits, energy efficiency labels.

Source: Authors.

[3] In the case of voluntary approaches, these legally binding obligations may not apply. Voluntary approaches aim to achieve policy objectives through co-operation and negotiated targets rather than through direct regulation.

2.2. Understanding the elements of the regulatory framework

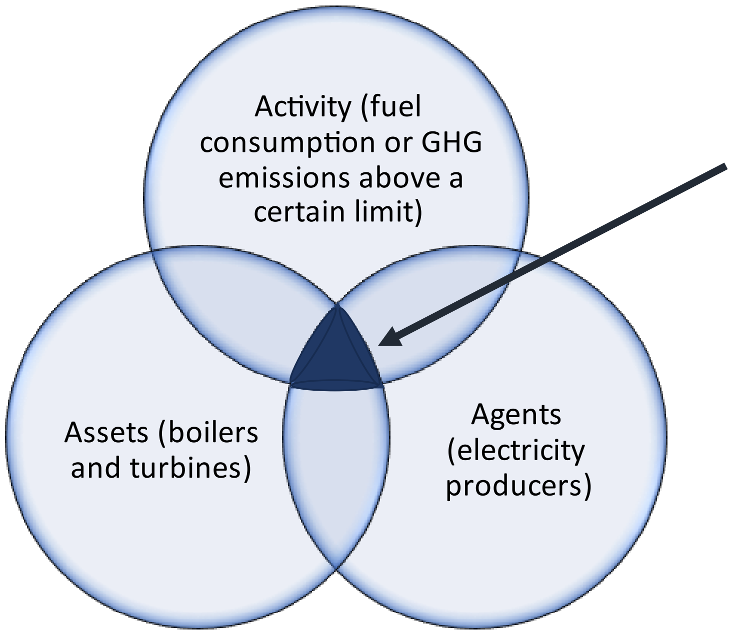
15. Policy instruments need a regulatory framework for their implementation. The regulatory framework defines who is regulated (the regulated agent), how they are regulated, how compliance is monitored and enforced, as well as other relevant administrative elements.

16. The regulatory framework also defines the **legal obligation** imposed on the regulated agents, which could be, for example, paying a tax, achieving an emissions standard, or adopting a specific technology. The legal obligation is usually framed in terms of a specific activity or action performed by the regulated agent, or the operational control of a held asset or a combination of both.

17. The **policy regulatory base (policy base for short)** defines who and what is subject to the instrument's legal obligation and hence defines the scope of the instrument. The policy base is the combination of agents, activities, and assets governed by the instrument. Within the policy base, the regulated **agent** is the legal entity (person or institution) that is required to fulfil the legal obligation and can be held accountable for non-compliance. The regulated **asset** is the physical object that is regulated, this can be a structure (e.g. boilers and turbines), a fuel (e.g. coal or gas) or can be more generic such as products and inputs The regulated **activity** refers to the actions or activities regulated by the policy instrument. These activities are usually the counterpart to the legal obligation, that will cause the expected changes in emissions and carried out by the regulated agent (driving at certain speeds, parking in certain places).

18. For reasons such as administrative efficiency, effectiveness, fairness, or coherence with other instruments, policymakers may restrict the scope of a policy instrument by limiting the number of agents subject to the legal obligation or the type of activities and assets affected. Criteria such as production, income, size, or geographic location, may be relevant to identify the agents affected by the regulation. Figure 1 provides a visual representation of the policy base. The figure presents how the interaction of the restrictions placed on agents, assets and activities may constrain the policy base in a way the limits the application of the policy instrument and therefore the emission base. For example, a possible policy base for the implementation of a GHG emission standard is an emission's threshold for electricity producers (agents) that consume fossil fuels to produce electricity (activity) or using boilers of a certain size (asset). Exemptions may narrow down the regulatory base even further, considering exempt facilities, regions, or fuels. Furthermore, specifications of implementation over time could alter the policy base, meaning that an instrument's emission base in one year could be smaller or larger than in a previous year.

Figure 1. The policy base



The **Policy Base** defines the scope of the policy instrument considering at least three dimensions: regulated agents, regulated assets, and the regulated activity. The figure illustratesthe case of a policy instrument designed for electricity producers (a subset of energy generators), that are using boilers and turbines to produce electricity that consume fuels above a certain threshold, where the policy base is represented by the shaded triangle representing the interaction of the three dimensions.

Following this example, heat production that does not generate electricity, or electricity producers that consume less than a certain amount of fuel (or generate less than a threshold of emissions) are excluded from the legal obligation defined in this policy instrument example.

Source: Authors.

2.3. The emission base

19. The *emission base* refers to the GHG emissions that a policy instrument covers through its policy structure. These emissions can be targeted as an explicit objective, in the case of climate change mitigation policy instruments (e.g. a carbon tax), or implicitly, in the case of climate change mitigation-relevant policy instruments (e.g. an excise tax). The emission base is determined by the policy base and the instrument's design. The policy base determines who and what is regulated, and the design establishes how the policy instrument operates to potentially reduce GHG emissions. The combination of both elements is critical to determine the emission base. The reason for this distinction is that not all policy instruments are structured to reduce emissions by reducing GHG emitting activities: some instruments are designed to promote assets that reduce emissions or enable emission reductions.

20. How the emission base is calculated is discussed in detail below. To do so, it is necessary to distinguish between asset types, what is referred to here as emission-relevant assets, and the associated policy design options.

2.4. Emission-relevant assets

21. GHG emissions can only be generated (or reduced) by performing an activity involving an asset that directly produces (or reduces) emissions or through the substitution of another asset that is more (less) emission intensive. These assets are referred to as **emission-relevant assets (ERAs)**. The concept of ERA is to develop a language to facilitate the distinction between different asset types and their impact on GHG emissions mapping. It is important to note that the ERA and the regulated asset do not necessarily have to be the same. Identifying the ERA associated with the policy instrument's design is the key to determining the emission base. For example, a policy instrument such as a subsidy or a time restriction may be designed to regulate the access of vehicles to the city centre using parking spaces. In this case

the object of the regulation, or the regulated asset, is the parking space, which is different from the ERAs affected by the regulation (which are primarily ICE passenger cars).

22. When a policy instrument does not directly regulate emissions, the link between the policy instrument and the emission base can be established through relevant assets. ERAs can be categorised into three categories:

- GHG-emitting assets: Assets that generate emissions. Examples include fossil fuels, assets that generate emissions through fuel combustion, such as thermal power plants, ICE vehicles or a steel manufacturing plant, as well as livestock in agriculture.
- Low-GHG-emitting assets: Assets that can function as substitutes for GHG-emitting assets but emit lower, zero or negative emissions when used. Examples are EVs, solar panels or energy management systems in industrial facilities. The category also includes assets that remove, capture or store GHG emissions.
- Enabling assets: Assets that promote (or reduce) the adoption of low-GHG or restrict (promote) the use of GHG-emitting (or low-emitting) assets. Examples include EV charging stations, designated parking spaces, and investments in pipelines.

23. When mapping policy instruments to their emission base, it is critical to understand whether the legal obligation operates directly on the ERAs that generate emissions (e.g. a tax on emissions) or indirectly through incentives generated by the policy instrument outside the policy base, that is by promoting actions that affect GHG emissions outside the assets regulated by the policy instrument (e.g. subsidising electric charging stations, that trigger emissions' reduction by incentivising an electric vehicle fleet). This depends on the policy instruments' design which is discussed below.

2.5. The policy instrument's design and its effect on emissions

24. Policy instruments impact GHG emissions by mandating or incentivising an agent to perform an activity that will reduce emissions. Some instruments are designed so that the legal obligation is directly related to the emission base by restricting or disincentivising the activities that generate emissions, for example a carbon tax or an emissions standard. In this case, the regulated agent is also the emitter, and the regulated asset is the source of emissions.

25. In other cases, however, the policy's impact on GHG emissions is indirect, as emitters or emitting assets lie outside of the instrument's regulatory/policy base. In effect the legal obligation generates an incentive for behaviour that affects emissions outside the direct purview of the policy instrument; for example, a policy instrument that requires producers to publish the GHG emissions generated by their product is designed to change the behaviour of consumers and affect the emissions by changing consumption patterns. In such cases, the identification of the relevant emission base becomes more complex. The specific case of indirect emissions control includes the value chain design and the substitution design.

26. The following sections discuss the three different policy instrument design options and their implications on emissions with concrete examples. Note that the term "design" here refers to the regulatory design specifying which emissions the instrument targets, not the operational details of how the instrument functions.

Instrument design 1: Emissions control covered by the regulatory policy base

27. Policy instruments can be designed to target the emissions covered by the policy base. As illustrated above, a carbon tax or an emission's standard would be an example of such a policy design. Regardless of how the policy instrument operates – whether a market-based or non-market-based instrument – the design approach is targeting the GHG emissions generated by the agents, assets and activities directly defined in the instrument's regulatory base. In this case, the instrument incentivises (or restricts) the activity of an agent who generates emissions through a high-emitting ERA (e.g., an electricity producer combusting fossil fuels) by obliging them to pay a price for each tonne of CO_2 emitted (or limiting the emissions legally possible).

Instrument design 2: Value Chain Design

28. Policy instruments can also be designed to affect or control emissions outside the regulatory policy base. There are two alternative approaches to policy design: value chain design or substitution design. These approaches are not mutually exclusive, meaning elements of both designs may be present in a specific policy instrument.

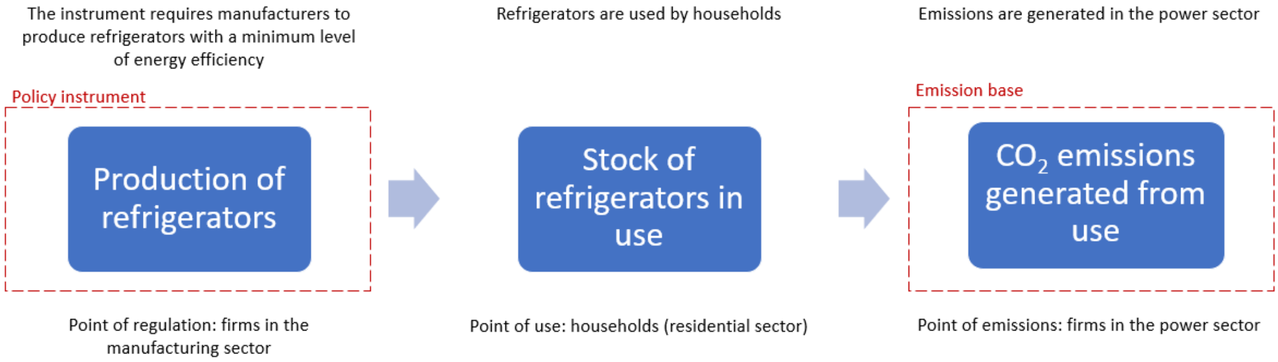
29. The **value chain design** involves policy instruments that regulate agents, assets or activities that do not directly generate emissions themselves. Instead, the regulation incentivises a change in behaviour that can potentially reduce emissions along the value chain. For example, consider an instrument that sets a minimum energy performance standard for refrigerators. The standard requires firms in the manufacturing sector to improve the technological design in the production of refrigerators, but the change in emissions materialises through reduced energy consumption when the refrigerator is used by households or businesses (who are not regulated by the policy instrument). Moreover, note that in this case, actual emissions from the regulated refrigerators will depend on the fuel sources in the power generation sector (Figure 2).

30. Another example of the value chain design can be seen in building codes that mandate new building to limit heating from fossil energy sources to a specific percentage of total energy use for heating. In this case, the regulation applies to building constructors, but the emission reduction occurs through reduced fossil fuel consumption by future residents.

31. The value chain design can distinguish between three "segments" of the value chain:

- 1) the point of **regulation** – where the policy instrument is enforced (in the examples above, the refrigerator manufacturers in the industry sector and the building constructors);
- 2) the point of **use** – where the services or activities that generate emissions are demanded (the households/consumers in the residential sector);
- 3) and the point of **emissions** – where the emissions are generated (fuels used for the electricity produced in the power sector).

Figure 2. Value chain design for emissions control through an energy efficiency standard



Source: Authors.

Instrument design 3: Substitution Design

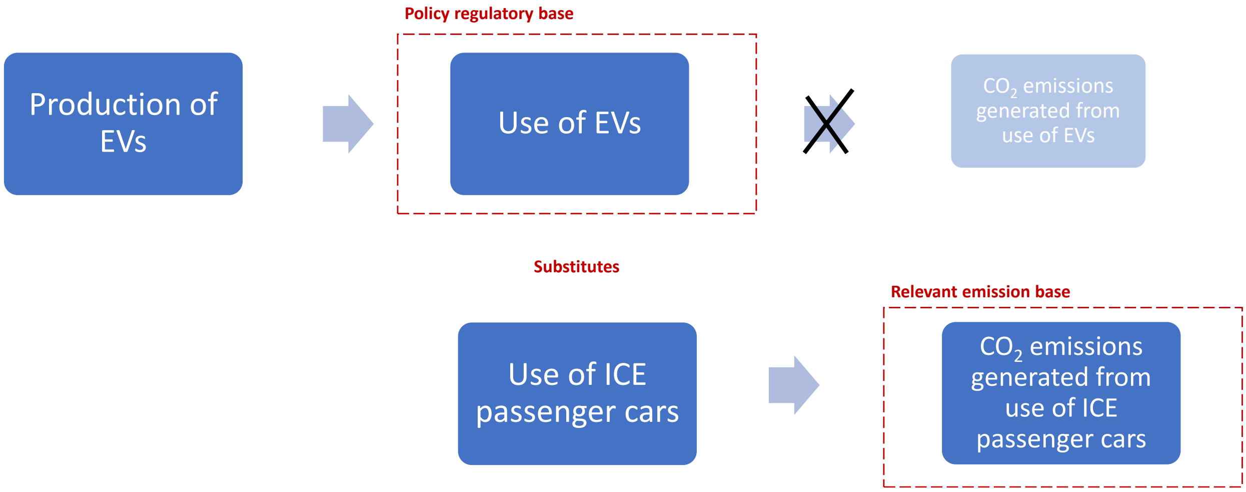
32. The **substitution design** is an approach to policy instrument design that targets emissions beyond the regulatory base. It involves instruments that aims to reduce emissions by promoting the uptake of low-GHG-emitting assets and substituting away from high-GHG-emitting assets. The substitution can be achieved either by incentivising or mandating low-GHG assets directly (e.g. an EV purchase subsidy or an EV sales mandate) or through enabling assets (e.g. a subsidy or requirement for building electric charging stations) to facilitate the uptake of low-GHG assets. In both cases, the design of the instrument is centred on replacing high-emitting with low-emitting assets that provide the same or similar services.

33. In the substitution design, the emissions generated by regulated agents or assets, and activities do not necessarily align with the emissions that are covered by the instrument. Consider the case of an EV purchase subsidy, which aims to reduce emissions from road transport by substituting ICE cars with EV cars. Here, the instrument's regulatory base comprises the buyers (agents) of EVs (assets). However, the emissions generated by the regulated assets (i.e. emissions from the use of EVs do not directly reflect the policymakers' primary objective. The policymaker is promoting EVs through a subsidy to target the emissions from ICE cars (i.e., the emission-relevant asset) by substituting them for EVs which do not generate emissions (Figure 3.).[4]

34. It is important to note that the emission base refers to the emissions generated by all assets potentially substituted, such as emissions from the existing fleet of assets that generate emissions. This is distinct from the *actual* effect on emissions, which will depend on multiple factors, including the substitution rate (e.g. the relative rate in the uptake of EVs vis-à-vis ICE passenger cars), the emissions-intensity of substituted assets (which may differ by substitute type, e.g. battery-electric vs. hybrid plug-in and fuel cell EVs), or even the use of the asset (e.g. a modal shift to other transport modes). All of this will depend on several conditions, including both the broader policy landscape as well as other market conditions, which will drive behaviour change. These are not considered here and can only be determined by modelling techniques to estimate the effect on emissions, an issue covered under Module 2 of the IFCMA.

[4] Note that this is not completely accurate since EV do generate emissions depending on the fuel sources from the electric grid, these are known as scope 2 emissions, and should also be considered.

Figure 3. Substitution design of an EV purchase subsidy



Source: Authors.

2.6. The relevant emission base

35. GHG mapping requires linking the policy instrument to the emission base. The link between the two will depend on the regulatory base and the regulated asset, the emission-relevant asset and the instrument's mitigation design: direct regulatory base emissions' design, value chain design, and substitution design.

36. In most cases, the emission base will be the emissions associated with the activity or assets described in the regulatory base. However, a difference will arise when the instrument's emission control design is indirect, i.e. when a value chain or substitution effect is present. In this case, for clarity, we will refer to the emissions from the regulatory base, that is the emissions generated by the regulated assets, as the ***regulatory* emission base,** and the emission base that the instrument targets, or unintentionally affects, as the ***relevant* emission base.** For example, consider the case of an EV purchase subsidy, the relevant emission base is the emissions from the passenger car fleet (comprised mostly of ICE vehicles), but the emissions of the regulatory base are the emissions from the EVs (which will largely depend on the electric power grid, scope 2 emissions).

37. The objective of GHG mapping is to quantify the *relevant* emissions base. Defining and quantifying the *regulatory* emission base may become relevant to determine the actual, net impact of the instrument on emissions. In effect, modelling exercises assess the impact of a policy instrument by estimating the final effect of the reduction of the emissions from the high-emitting asset (in this case ICE cars) substituted by the low(er)-emitting assets (in this case EVs), the difference will be the effective total emissions.

3. A GHG mapping methodology

38. A GHG emissions mapping methodology involves identifying and quantifying the emission base of a policy instrument and allocating those emissions to relevant classification categories for analysis. The choice of classification category to use will depends on the specific analytical objective. GHG emission trajectories are typically monitored using emission source sectors defined by the Intergovernmental Panel on Climate Change (IPCC), while economic modelling often involves mapping to economic sectors, based on standards like the International Standard Industrial Classification of All Economic Activities (ISIC) or the Statistical Classification of Economic Activities in the European Community (NACE).

39. Mapping does not estimate the effects of policy instruments on emissions. Actual impacts depend on various conditions, and require modelling techniques, which are covered in Module 2 of the IFCMA. GHG emissions mapping is a static description of the scope of the policy in a specific point in time.[5] It aides in identifying instruments that should be prioritised for evaluation and potential reform, especially when economic impact analyses are not available.

40. In addition, mapping can help in pinpointing (sub)sectors that may benefit from further policy attention or focus, or identify countries that succeed in tackling a considerable share of emissions in hard-to-decarbonise sectors. Mapping can also highlight overlaps where multiple instruments address the same emission base. These overlaps – or their absence – indicate possible interaction effects and synergies among the instruments that can significantly influence the effectiveness of individual policy instruments, or an entire policy package.

41. Moreover, determining the emission base is crucial for comparing different policy approaches within and across countries. For instance, when analysing carbon taxes, the tax rate is a key descriptor, and often cited as an indicator of policy ambition. The emission base can enhance this analysis by highlighting the instrument's scope: e.g., some countries may apply the tax economy-wide, while others may limit it to specific fuels or entities. The emission base also helps contextualise and interpret comparisons. For example, an emission tax on coal with the same tax rate (or a coal ban) has different implications in a country where coal combustion accounts for 10% of total emissions versus another where it accounts for 90%.

42. The OECD's work on *Taxing Energy Use* and *Effective Carbon Rates* has illustrated the application and value of mapping for carbon-pricing related instruments for many years (Box 1). The aim of the IFCMA is to extend this work and broaden it to other types of policy instruments.

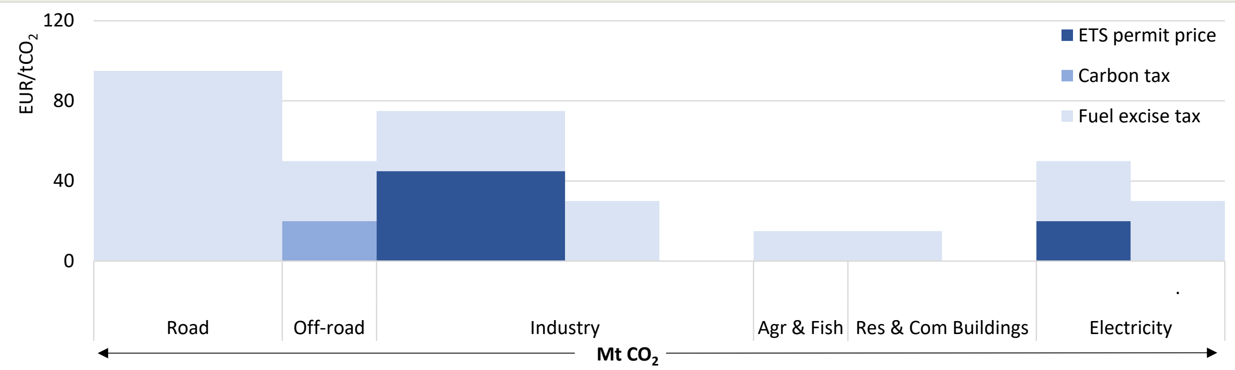
[5] In the Swiss and Chilean pilot, the policy stocktake captured policies as of 2023 and 2024, respectively, and mapped to the latest available emissions data (2021 and 2020, respectively).

Box 1. The OECD's Effective Carbon Rates

The IFCMA's GHG mapping builds on the long-standing experience in emissions mapping of the **Effective Carbon Rates (ECR)** database. The ECR database contains harmonised and comparable information on carbon pricing instruments across countries and over time, enabling like-for-like comparisons and informing policy reform. It publishes an indicator (the ECR) based on three climate change mitigation policy instruments whose regulatory base is either GHG emissions or is directly proportional to GHG emissions (e.g. fossil fuel use). The three policy instruments are emissions trading systems (ETS), carbon taxes and fuel excise taxes. The ECR is calculated as the sum of ETS permit prices and the two taxes and expressed in EUR per ton of CO_2 equivalent (tCO_2e).

The database not only takes stock of policy instruments and their intensity level, but also maps them to the corresponding energy use and emission base. ECR coverage includes six sectors spanning all energy uses and ten fuel categories (including fossil fuels and other combustibles). Emissions and energy use are allocated to the primary sector where the energy is consumed. In the most recent updates, the ECR database also considers other GHG emissions and further introduced a new indicator, the "net ECR", which also includes selected fossil fuel subsidies.

Figure 4. Illustration of a fictional country's Effective Carbon Rates (ECR), mapped to CO_2 emissions from energy use, by sector



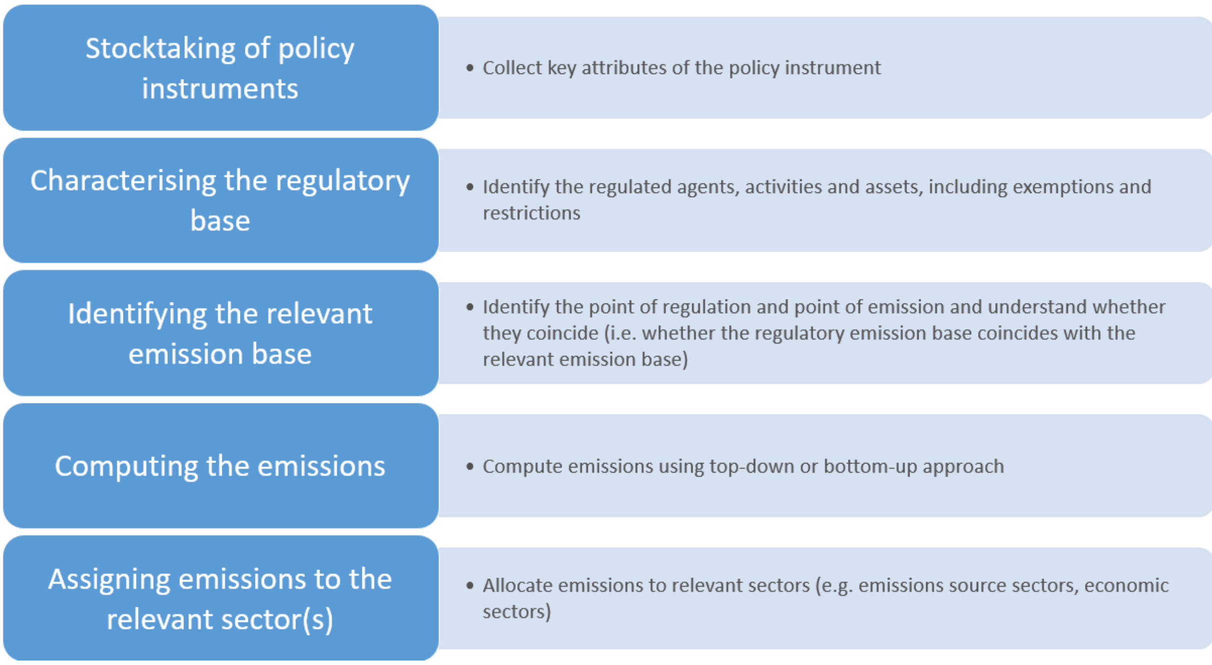
As a result, the three policy instruments and the components of the ECR can be mapped to the emissions that they apply to. Figure 4. presents a simplified illustration of a fictional country's ECR levels and the CO_2 emissions from energy use bases of the three instruments by sector. The figure shows that fuel excise taxes are applied to activities in all sectors and cover more than 80% of the country's energy-related CO_2 emissions. The ETS covers emissions in industry and electricity generation, while a carbon tax only applies to emissions that occur in off-road transport. As the ECR mapping accounts for overlaps in policies and for tax rate variations (e.g. exemptions, reduced rates), the ECR effectively visualises and reveals any large heterogeneities in effective tax rates between sectors.

Source: Authors.

3.1. Five steps towards GHG emissions mapping

43. Determining the emission base of an instrument involves several steps. As a starting point, it is necessary to understand how the policy instrument operates, and clearly identify the regulatory base. It also requires determining whether the assets covered by the regulatory base are the source of the emissions or whether the emission base is outside the scope of the regulatory base coverage. Once the point of emission is identified, the emission base can be quantified and allocated to a specific sector. Figure 5 summarises the five steps, which are described in detail in the following sections.

Figure 5. Five steps towards GHG emissions mapping



Source: Authors.

I. Stocktaking of policy instruments

44. The first step in the GHG emissions mapping is to carry out a comprehensive description of the policy instrument. This requires collecting information from the legislation or regulatory framework on the attributes that characterise the design and operation of the instrument, for example elements such as geographic scope (i.e. where does the instrument apply), the temporal scope (when and for how long will it be in force), and sector coverage, among others.

45. For the mapping, it is necessary to identify key attributes such as the policy instrument type (i.e., mitigation or mitigation-relevant instrument), which can be derived from the stated policy objective, as well as the policy design, which yields insights on how it may impact GHG emissions. The latter involves understanding whether the policy instrument directly regulates an agent, an asset or an activity that emits GHG emissions, or whether it affects emissions indirectly because its design leads to a value chain or substitution effect. In case of the latter, the GHG emissions mapping process will require careful consideration of the regulatory base, the point of regulation and the point of emission. Table 2 presents examples of how different policy instruments could be characterised.

Table 2. Examples of characterisation of policy instruments

Policy instrument	Type	Stated objective	Relevance for GHG emissions	Policy design
Coal plant CO_2 emissions standard	Mitigation	Eliminate CO_2 emissions from coal plants	-	Direct Regulatory Base
Speed limit on highways	Mitigation-relevant	Enhance road safety	Reduced CO_2 emissions through less fuel use	Direct Regulatory Base
EV purchase subsidy	Mitigation	Reduce emissions from ICE passenger cars by promoting the uptake of EVs	-	Substitution
Vehicle fuel efficiency standard	Mitigation-relevant	Reduce fuel use in road transport	Reduce emissions from ICE vehicles	Value chain
Carbon tax	Mitigation	Reduce emissions in the power generation sector	-	Direct Regulatory Base

Source: Authors.

II. Characterising the regulatory base

46. Starting from the general assessment of the policy instrument in Step 1, the next step requires a precise characterisation of the regulatory base according to its different components. This means defining the regulated agent, activities, the regulated asset, including exceptions and restrictions.

47. In most cases, the regulatory framework restricts the scope of the instrument to a group of agents, assets or activities. To specifically identify the regulatory base, it is necessary to identify the subset of agents that are affected by the legal obligation, in conjunction with the precisely regulated assets and activity. For example, a carbon tax can apply to power generators (agents), but only those that emit more than 10 000 tonnes of CO_2 per year. Restrictions on the regulated activity and assets may further narrow the regulatory base (e.g., when facilities using peat or biofuels are exempt). Table 3 provides examples of the regulatory bases of different policy instruments.

Table 3. Examples of characterisation of the regulatory base

Policy instrument	Regulated agents			Regulated activities		Regulated assets	
	Legal obligation	**Agent**	**Scope**	**Activity**	**Scope**	**Asset**	**Scope**
Coal plant CO_2 emissions standard	Comply with emissions standard on plant operation	Power generation facility operators	Power generation facilities that use coal as a fuel source	Emissions of GHGs from power generation	Emissions above a threshold	Coal plants	Exempted: peat
Vehicle fuel efficiency standard	Comply with efficiency standard on cars	Car manufacturers/ importers	Producers selling more than 1000 vehicles per year	Production with a specific performance requirement	Not applicable	Passenger cars	New ICE passenger cars; cars for people with disabilities are exempt
EV purchase subsidy	Acquire the purchased EV to obtain a subsidy	Purchasers of EV passenger vehicles	EV owners with an annual income of less than EUR 100 000 per year	Purchase EVs	Households	EV	New EV, with purchase prices below EUR 60 000
Carbon tax	Pay a tax on emissions	Power generation facilities	Power generators emitting more than 10 000 tonnes of CO_2 per year	Emissions of GHGs from power generation	Excluding emissions in emergencies	CO_2 emissions or fuels	Fuel types (excluding peat or biofuels)

Source: Authors.

III. Identifying the relevant emission base

48. Step 3 identifies the relevant emission base. Doing so requires an understanding of the policy design (Step 1), the precise regulatory base (Step 2), and the identification of the emission-relevant assets, which may or may not be equal to the regulated asset. To recap, the policy design will provide information on how the instrument affects GHG emissions (whether it directly regulates emissions or a GHG-emitting asset; or whether its effect on emissions is indirect, through the value chain and substitution effect); whereas the regulatory base precisely identifies who and what is regulated by the instrument.

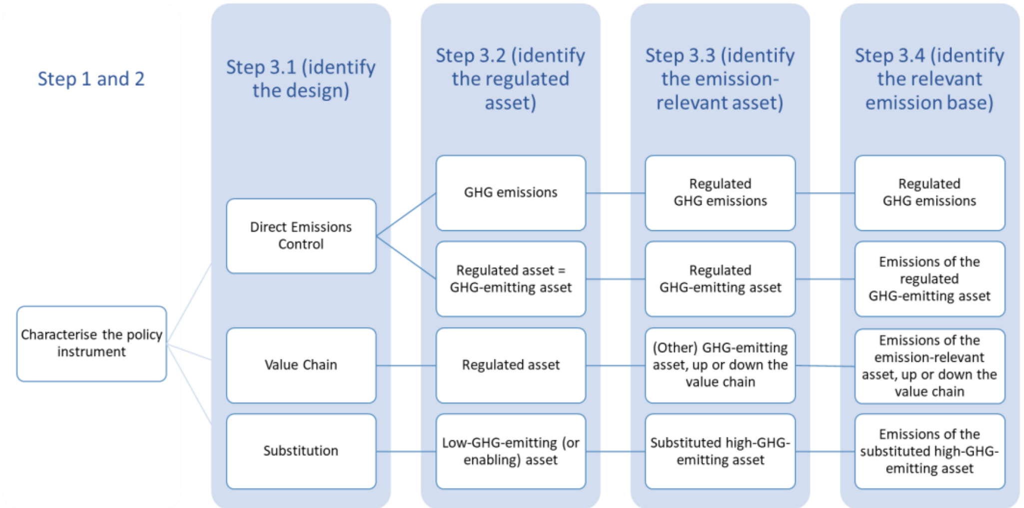
49. In the case of a direct emissions control policy design, identifying the relevant emission base is relatively straightforward: it equals the regulated asset, as identified in Step 2. If the instrument directly regulates GHG emissions (e.g. a carbon tax), relevant emission base equals the regulatory emission base (i.e. CO_2 emissions). If it directly regulates assets that emit GHGs (e.g. an ICE vehicle ban), the relevant emission base will be the emissions from these regulated assets (i.e. emissions from ICE vehicles).

50. In the case of an indirect policy design, identifying the relevant emission base can be complex, as the regulated asset (or the regulated agent or activity) is different from the asset (and/or agent or activity) that causes the emissions. The critical step in these cases is the identification of the emission-relevant asset and the point of emissions. For example, consider the policy instrument with a value chain design discussed in Section 2, a minimum energy performance standard for refrigerators. In this case, the regulated asset is a refrigerator; and it is also the emissions-relevant asset. However, the point of regulation is different from the point of emissions. The instrument regulates firms in the manufacturing sector (this would be the point of regulation), but the change in emissions materialises through reduced energy consumption by households or businesses (the point of use). Actual emissions will depend on the fuel sources in the power generation sector (point of emissions), otherwise called Scope 2 emissions.

51. Similarly, if an instrument operates by substituting a high-GHG-emitting with a low-GHG-emitting asset (or by promoting the uptake of low-GHG-emitting assets), the relevant emission base does not equal the emissions of the regulatory base, but the emissions of the asset that is being replaced. Using the example of an EV purchase subsidy discussed in Section 2, the emission-relevant assets are the ICE cars that are being replaced. In order words, the relevant emissions are the emissions from ICE cars.

52. Figure 6 illustrates how the relevant emission base differs, depending on policy design, the regulated emission base, and the emission-relevant assets.

Figure 6. Step-by-step approach to identify the relevant emission base.



Source: Authors.

IV. *Computing the emissions*

53. Once the emission base is identified, total covered emissions can be computed. This is Step 4. It will require granular data on emissions and, if not available, data on activities, inputs or assets that can facilitate estimation, for example energy consumption or the stock composition of the relevant assets. The complexity of computing or estimating the emission base will depend on the specific instrument (for example, how narrow the regulatory base is). Assumptions and a simplifying use of emission factors may be necessary for a list of policy instruments to arrive at a reliable coverage estimate. For particularly complex cases such as forestry policies covering emissions from complex ecosystem interactions, the results may underly additional caveats reflecting the highly dynamic physical changes in this sector which may not be reflected in the employed emission data. Generally, there are two possible approaches to compute emissions: the top-down approach, and the bottom-up approach. These two approaches involve trade-offs between feasibility and accuracy.

54. The top-down approach involves a broad survey of the emissions or emission-relevant assets subject to the policy instrument. One option is to estimate the instruments' emission coverage by subtracting those emissions of excluded sectors or activities from total emissions assigned to a sector or related to an activity. For example, the Swedish carbon tax affects fuel combustion excluding the entities covered by the EU-ETS. An approximation of the emission base of the tax would be the emissions from the energy sector minus the emissions from industries regulated under the ETS. The bottom-up approach would be much more precise but more data intensive. It would require identifying the agents, and emission-relevant assets affected by the instrument, and subsequently estimating the emissions starting from those emitted by the emission-relevant assets. In the case of market-based policy instruments, such as carbon taxes and ETS, administrative records of emissions may be available at the installation level or firm level. Alternatively, emissions can be estimated using emission factors related to a particular asset and information on production levels.

55. It is important to note that in addition to data limitations, there may be conflicting or competing data sources associated with different methodologies and approaches (Sakata, Aklilu and Pizarro, 2024[3]). Therefore, standardised criteria for data sources must be established within this methodology. Different data sources will be used during the pilot phase to guide the development of criteria for a data source hierarchy considering trade-offs between resource intensity and accuracy.

IV. Assigning emissions to the relevant sector(s)

56. Once the emissions are computed under Step 4, the GHG emissions are attributed to analytically relevant categories. One approach is to allocate emissions to IPCC emission source sectors. Another approach is to allocate emissions to economic sectors as defined in the ISIC classification structure, which is more relevant to the modelling of the effects of policy instruments. IPCC emission source sectors are defined in terms of technological sectors; therefore, the classification of emissions depend on the emission-relevant asset. By contrast, ISIC sector classification will depend on the economic activity of the agent. For more details see Box 2. It is important to underscore that a policy instrument may have an emission base spanning different sectors and emission sources. A comprehensive analysis of what is possible will be determined through the IFCMA pilots.

Box 2. Classification standards and categories

The IPCC emissions source classifications refer to emissions based on the actual physical sources that generate emissions. The ISIC structure classifies productive activities according to the inputs of goods, services, and factors of production; the process and technology of production; the characteristics of outputs; and the use to which the outputs are put (United Nations, 2008[4]).

Both IPCC and ISIC systems provide a classification of activities according to a hierarchical structure with categories and sub-categories. The most aggregated level of the IPCC classification system refers to five sectors. In the case of the ISIC classification the highest level is a letter-level grouping called "sections" which are further divided into the 2-digit "divisions", 3-digit "groups" and 4-digit "classes". Due to the different classification principles, emissions from the same source can be grouped into different sector categories. For example, according to the IPCC classification, emissions from agricultural transport are classified under the transport category in the energy sector. However, since the ISIC classification is based on the principal activity of the firm – defined as "the activity whose value added exceeds that of any other activity carried out within the same unit" in the System of National Accounts (SNA), these emissions would be classified under the agricultural sector (A: "Agriculture, forestry and fishing"). Emissions from transport activities would only be allocated to transport sector (H: "Transportation and storage") when the principal activity of the firm is transportation, that is it provides transportation services (Flachenecker, Guidetti and Pionnier, 2018[5]).

Which sector classification to use to map emissions will depend on the analytical objective. Classifying emissions by source makes it possible to monitor emissions from transport across all economic sectors and is relevant for policy making when implementing policy on instruments, such as fuels. On the other hand, classifying emissions according to economic sectors facilitates policy making focused on economic activities, and allows meaningful comparison of GHG emissions with other economic data, for example with value added and employment.

Source: Source: Sakata, Aklilu and Pizarro (2024[3]), Greenhouse gas emissions data: Concepts and data availability", *OECD Statistics Working Papers*.

3.2. Mapping GHG emissions over time

57. While the GHG mapping exercise provides a static snapshot, the emission base recorded may change over time as emissions data is updated. The emission base will vary over time depending on the implementation of the policy instrument and the evolution of the stock of the emission-relevant asset considered in the policy base.

58. Furthermore, a policy instrument typically operates over a period of time. Estimating the emission base will depend on the maturity of the policy instruments and its adoption rate over time. To illustrate this issue, consider a policy instrument that regulates new assets that enter a market, for example an energy efficiency standard for new refrigerators.

59. The regulated agents are the producers or importers of refrigerators, and the emission-relevant assets are new refrigerators. The policy instrument operates through substitution, replacing old inefficient refrigerators with new, more efficient, refrigerators. Also, the point of emissions is different from the point of regulation, total emissions will depend on the refrigerator's electricity consumption and in turn the emissions from the combustion of fuels in the power generation. Therefore, both the substitution and value chain design issues are present.

60. In this case, the emissions of the policy base – from new refrigerators – will vary over time as new refrigerators enter the market and are used. Further, the relevant emission base will be the emissions of all the refrigerators currently in use. These are the emissions that the policy instrument is designed to target. The net impact of the policy on emission is reflected in the difference between the current emissions from refrigerators and the emissions resulting from the introduction of the new, more energy-efficient refrigerators, taking into account the rate of uptake of the new refrigerators, which will in turn is influenced by local and global market conditions, etc. The policy instrument will mature when the stock of emission-relevant assets matures, i.e. when all old refrigerators are completely replaced. Box 3 provides an example.

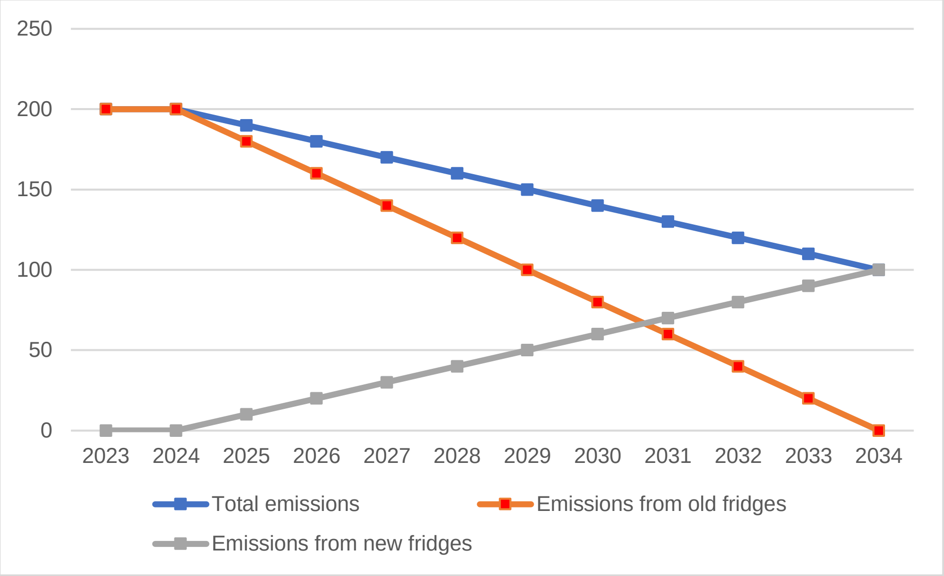
Box 3. A policy instrument regulating new emission-relevant assets

Consider for instance a policy instrument that requires new refrigerators to have at least an energy efficiency of 280 kWh per year from 2025. The policy instrument operates by changing the emissions of new refrigerators and slowly changing the total emissions of the stock of refrigerators as new refrigerators replace old ones. The policy instrument will mature when the stock of new refrigerators replaces the old ones, say 2033. Total GHG emissions will depend on the stock of refrigerators at a given point in time which will include old and new refrigerators, which in turn will depend on the introduction of the new refrigerator and the growth rate of the stock. The table below illustrates the different emission base, and the effective emissions.

Table 4. Evolution of the emission base over time

	Emissions from the regulatory base (new efficient refrigerators)	**Relevant emission base** (old inefficient refrigerators to be replaced)	**Emissions of the entire stock** (stock of refrigerators currently in operation)
Year 2023	Zero	GHG emissions of the stock of old refrigerators in use	GHG emissions of the stock of refrigerators in use
Year 2024	Zero	GHG emissions of the stock of old refrigerators in use	GHG emissions of the stock of refrigerators in use
Year 2025	Emissions of new refrigerators	GHG emissions of the stock of old refrigerators in use	GHG emissions of the stock of refrigerators in use now including new refrigerators
Year …	…	…	…
Year 2033 (policy instrument has matured)	Emissions of new refrigerators that now have replaced the old stock	GHG emissions of the stock of old refrigerators in use	GHG emissions of the stock of refrigerators in use now completely covered by new refrigerators

Figure 7. Regulatory emission base and relevant emission base



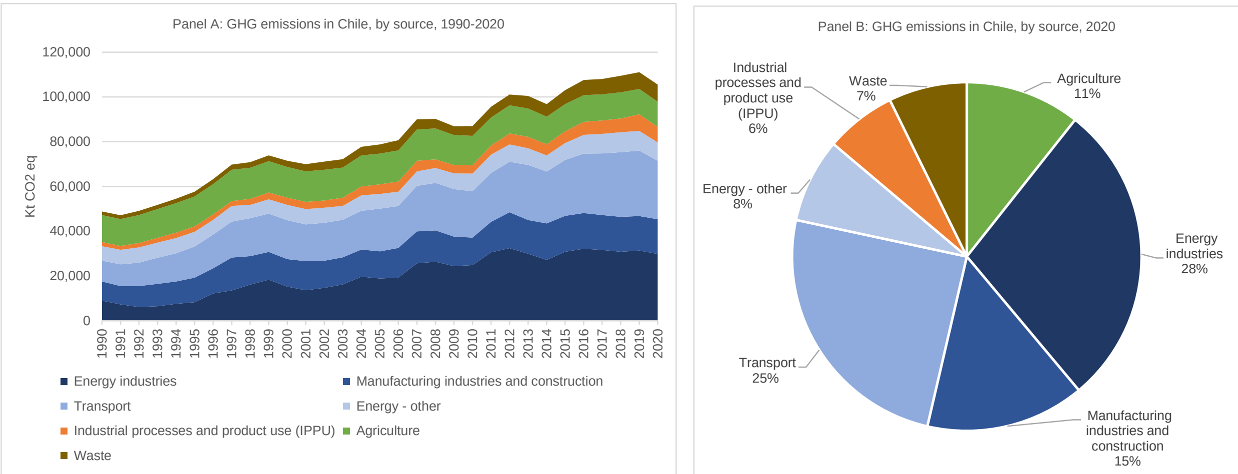
Note: The emission base of this instrument regulating only new refrigerators grows over time, as new refrigerators enter the market. The relevant emission base of the instrument is all emissions from refrigerators when the instrument is introduced in 2023 (t=1).
Source: Authors.

4. Selected examples of GHG mapping from the Chilean pilot study

61. Pilot studies are a key feature of the methodological development of the IFCMA work. They are necessary not only for gathering granular data to carry out real world examples, but more importantly test and refine new methodological approaches. The following examples draw from information provided by Chile, one of the IFCMA pilot countries. It is important to note that these results are preliminary and await formal validation.

62. Chile has a population of 20 million inhabitants, with a GDP of USD 402.8 billion in 2022 (OECD, 2022[6]). Its GDP per capita is the highest in South America with USD 23 716 in purchasing power parities (OECD, 2022[6]). The economy is based on industry and services sustained by processing natural resources, such as minerals, forestry, and fisheries. In 2020 energy industries was the most emitting sector in the country, representing around 28% of gross GHG emissions (i.e. excluding land use, land-use change and forestry), followed by road transportation, representing 25% of total emissions.

Figure 8. Chile's GHG emission profile



Note: IPPU = industrial processes and product use. Emissions exclude emissions from land use, land use change and forestry.
Source: Ministerio del Medio Ambiente. (2023). Informe del Inventario Nacional de Chile 2022: Inventario nacional de gases de efecto invernadero y otros contaminantes climáticos 1990-2020. División de Cambio Climático. Santiago, Chile.

4.1. Example 1: The Chilean carbon tax

Steps involved in mapping the Chilean carbon tax to the GHG emissions it covers

63. ***Step 1*** requires a detailed understanding and characterisation of the policy instrument (see Table 5). Chile's carbon tax is a national policy instrument designed to support efforts to decrease air pollution and GHG emissions and has been in operation since 2017. The carbon tax is set directly on CO_2

emissions generated originally from stationary sources that contain boilers and turbines that have a total aggregate thermal energy capacity of 50 MW or more (regulated assets). In a later reform, in 2021, the tax was set on any structure that generates more than 10 000 tonnes of CO_2 in a year, this implies that assets covered by the regulatory base have changed and therefore so has the emission base. The tax threshold changed from 2023, from installed capacity to an emissions threshold, i.e., 25,000 tons of CO_2 and/or 100 tons of PM, measured on an annual basis. An offset system was also added to alleviate the payment of the tax, or to promote mitigation in non-regulated sectors, with the goal of creating a domestic offset market.

64. After characterising the overall policy, ***Step 2*** involves the precise identification of the instrument's regulatory base which defines the instrument's scope. In this example, we use the Chilean carbon tax as originally designed, that is levied on operators of facilities that have boilers and turbines considering a technological threshold of 50 MW which covers large installations of both power generation as well as heat production in industrial processes, specifically food production, pulp and paper, and refineries. The legal obligation imposed on the regulated agents is to pay USD 5 for the release of each tonne of CO_2 regardless of total emissions.

65. Since the policy instrument's design has a direct regulatory base, the identification of the relevant emission base, required in ***Step 3***, is relatively straightforward. In this setup, the regulated asset coincides with the emission-relevant asset, i.e. the regulatory emission base and relevant emission base are the same.

66. ***Step 4***, the computation of the emission base, depends on available data sources. In Chile's context, regulated agents must report their emissions, which allows for the quantification of the emission base through a bottom-up approach, i.e. by summing up the CO_2 emissions reported by each regulated entity.

67. Finally, ***in Step 5***, emissions are assigned to relevant sectors. When using a bottom-up approach, this can be done by allocating each individual reporting facility to the relevant sector, which could be based on IPCC source sectors, ISIC classification of economic sectors, geographic or demographic classifications, or other. An illustration on how data from the Chilean database on emissions at facility level can be used to allocate emissions to different sectors is shown in Figure 9. When such detailed emissions data is not available, apportioning emissions to specific sectors or groups may be more complex. Approaches and methodologies for mapping in such cases will be explored in more detail in subsequent papers.

Table 5. Selected attributes from the IFCMA stocktake of the Chilean carbon tax

	Attribute	Detail
Administrative information	Instrument name	Green tax on stationary sources
	Country	Chile
	Jurisdiction	National
	Enactment date	2014
	Entry into force	2017
	End date	None
Classification	Instrument family	Economic instrument/ Market-based instrument
	Instrument type	Tax
	Instrument	Carbon tax
	Mitigation design	Direct
Policy design	Description	An annual tax on carbon dioxide (CO_2) emissions, produced by facilities with boilers and turbines whose emitting sources, individually or as a whole have a thermal power capacity of 50MW.
	Stated objective	Reduce CO_2 emissions
	Intensity	5 USD / tCO_2

Regulatory base	**Regulated agents**	Operators of facilities with boilers and turbines
	Regulated activity	Emissions of CO_2
	Regulated asset	Boilers and turbines with a collective thermal power capacity of 50 MW or more

Note: the table presents an extract of the policy stocktake. Attributes that are particularly relevant to GHG mapping are marked in bold. For consistency reasons in the mapping exercise, the table presents the carbon tax as of 2020 (as per the last year available in the National Inventory Report). It is important to note Law No. 21,210, on tax modernization approved in 2020, through its Article 16, replaced the technical threshold (50 MWt) with an emissions threshold, taxing establishments whose emitting sources that individually or as a whole emit 100 or more annual tons of particulate matter (PM) or 25,000 or more annual tons of carbon dioxide (CO_2). This new limit, along with other modernization changes (offset system), became effective in 2023. The tax threshold changed from 2023, from installed capacity to an emissions threshold, i.e., 25,000 tons of CO_2 and/or 100 tons of PM, measured on an annual basis. An offset system was also added to alleviate the payment of the tax, or to promote mitigation in non-regulated sectors, with the goal of creating a domestic offset market.
Source: Authors.

Figure 9. Illustration on how to aggregate CO_2 emissions from the Chilean carbon tax and allocate them to different sectors

Facility	Year	Emissions	Sector
Facility 1	2019	890 000	A
Facility 1	2020	870 000	A
Facility 2	2019	58 500	B
Facility 2	2020	56 000	B
Facility 3	2019	342 000	B
Facility 3	2020	297 000	B

Emissions 2019	
Sector A	890 000
Sector B	400 500

Emissions 2020	
Sector A	870 000
Sector B	353 000

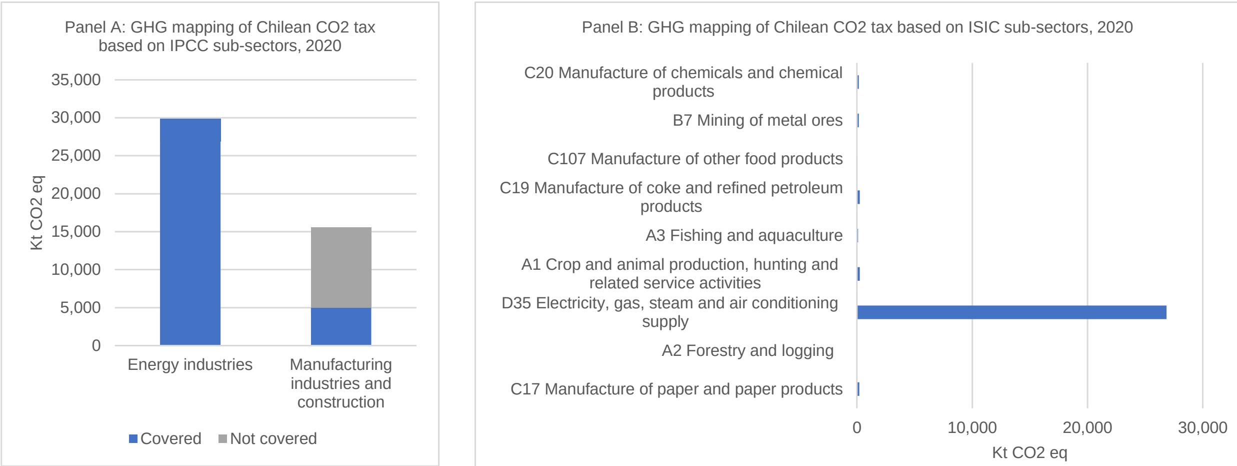
Note: Data presented is for illustration only; it does not match the emissions reported under Chile's carbon tax.
Source: Authors.

Preliminary results: mapping the Chilean carbon tax to selected analytical categories

68. Figure 10 presents preliminary results for the GHG mapping of the carbon tax for Chile, for both IPCC (Panel A) and ISIC (Panel B) sector classifications. The results show that the carbon tax covered around 40% of total national GHG emissions in 2020. When mapping to IPCC emission source sectors, the carbon tax mostly covered two sectors: energy industries (where all emissions are covered) as well as manufacturing industries and construction (where about 30% are covered). It also covers a very small share of emissions from energy used in agriculture and fishing activities. When mapping to ISIC sectors, the tax principally covered electricity generation, with coverage of several other sectors, although the amount of emissions from the latter are relatively small. Note, however, that this will change in the future, since the tax was adjusted in 2021 to cover other sectors such as mining and cement production.

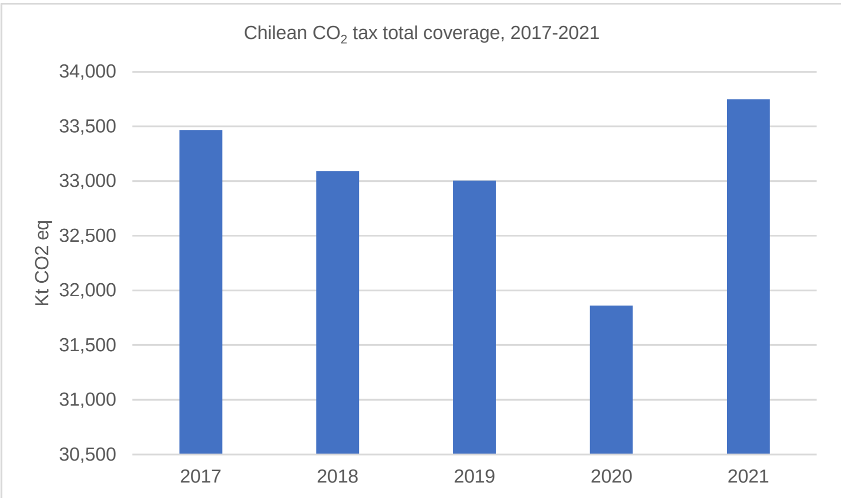
69. Moreover, since information is available for several years, it is possible to visualise the evolution of the carbon tax's emissions coverage over time (Figure 11).

Figure 10. GHG mapping of the Chilean carbon tax



Note: Preliminary results. Estimates based on MRV data from the Chilean Ministry of Environment, dating to 2022. Both figures exclude negligible emissions from energy used in agriculture and fisheries.
Source: Authors.

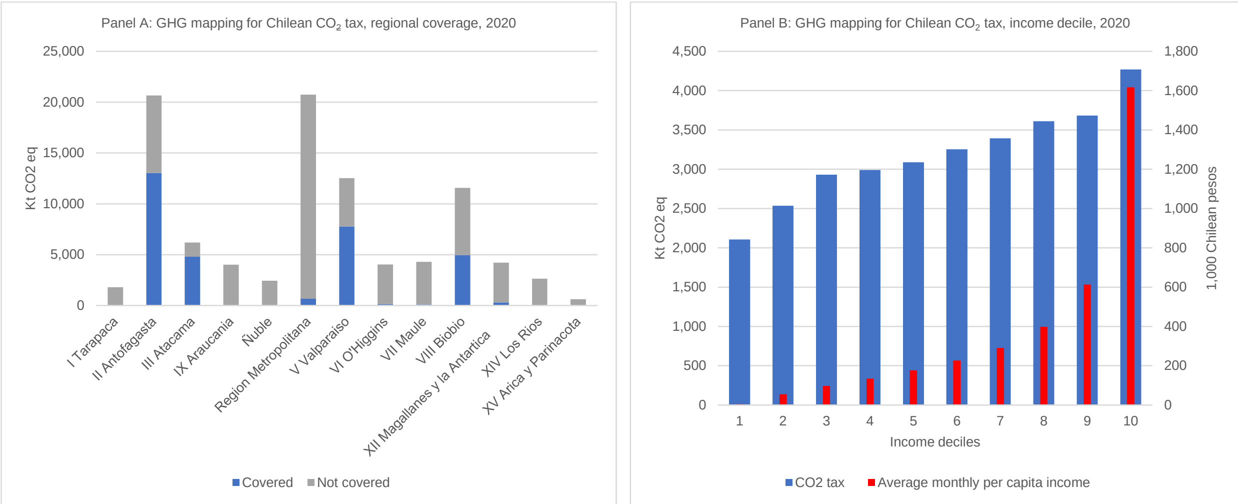
Figure 11. Chilean carbon tax coverage, 2017-2021



Note: Preliminary results. Estimates based on MRV data from the Chilean Ministry of Environment, dating to 2022.
Source: Authors.

70. When detailed information is available, additional GHG mapping exercises that can support other analytical objectives are possible. For example, Panel A in Figure 12 presents GHG mapping at the subnational level, considering GHG emissions of facilities in different regions. Although not currently one of IFCMA's objectives, Panel B in Figure 12 presents a possible GHG mapping taking into account the distribution of the covered emissions by the tax considering the electricity consumption of households according to income deciles.

Figure 12. Chilean carbon tax coverage trend



Note: Preliminary results. Estimates based on MRV data from the Chilean Ministry of Environment, dating to 2022. Panel B compares income deciles (in red) with CO_2 emissions calculated based on a weighted average of the electricity consumption and linearly mapping to CO_2 emissions. Regional emissions exclude LULUCF.
Source: Authors.

4.2. Example 2: The phase-out of coal-fired power generation in Chile

Steps involved in mapping the coal phase-out to the GHG emissions it covers

71. In 2019 the Chilean government reached an agreement with the electricity generators to close all of Chile's coal-fired power plants by 2040. This is a voluntary agreement that operates as a direct ban. It can be considered a policy instrument that operates with a direct regulatory base emissions control design: it reduces and will eventually eliminate CO_2 emissions by banning the construction of and gradually phasing-out the operation of coal-based thermal power plants (***Step 1***).

72. The regulatory base (***Step 2***) can be determined from the document that establishes the agreement. The ban affects owners and operators (agents) of power plants generating electricity using coal as a fuel source (assets and activity). The agreement was reached in close collaboration with the plants' owners and defines specific dates for each power plant to be phased out according to the owners' needs and the stability of the national grid. Some coal-fired electricity generation plants were closed at the time the agreement was reached (2019), others closed in 2020, 2022 and 2023, and others will close in 2024 and 2040, reaching the total phase-out expected by this time.

73. Identifying the relevant emission base (***Step 3***) is again relatively straightforward due to the direct emission control design of the coal phase-out. In this setup, the regulated asset coincides with the emission-relevant asset, , i.e. the regulatory emission base and relevant emission base are the same.

74. The emission base can be computed (***Step 4***) using the same dataset on emissions reported by facilities covered by the carbon tax, given that all coal-fired power generation facilities are subject to the carbon tax and hence report their emissions to the Chilean authorities. The emission base of the phase-out can, therefore, be calculated by aggregating the reported emissions from coal-fired power generation facilities. Finally, emissions can be assigned to specific sectors and groups, by assigning each individual facility and summing up facilities in the same category or group.

Table 6. Selected attributes from the IFCMA stocktake of the Chilean coal phase-out

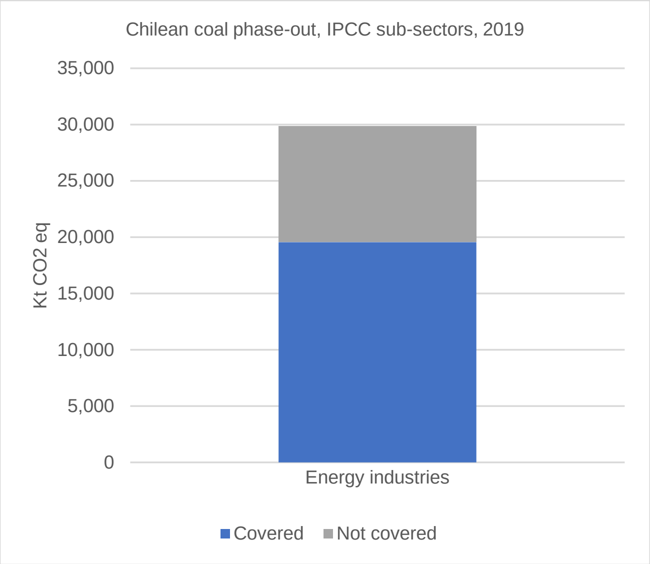
	Attribute	Detail
Administrative information	Instrument name	Retirement agreements for coal-fired thermoelectric plants
	Country	Chile
	Jurisdiction	National
	Enactment date	2019
	Entry into force	2019
	End date	N/A
Classification	Instrument family	Non-market-based instrument
	Instrument type	Voluntary approaches, Technology standard
	Instrument	Ban/ phases-out
	Mitigation design	Direct
Policy design	Description	The Ministry of Energy reached an agreement with energy generation firms in order to phase-out thermo-electrical centrals by 2040
	Stated objective	Phase-out thermo-electrical centrals by 2040
	Intensity	N/A
Regulatory base	**Regulated agents**	Coal-fired thermoelectric plants operators
	Regulated activity	Electricity production in coal-fired thermoelectric plants
	Regulated asset	Coal-fired thermoelectric plants

Note: the table presents an extract of the policy stocktake. Attributes that are particularly relevant to GHG mapping are marked in bold.
Source: Authors.

Preliminary results: mapping the Chilean coal phase-out to selected analytical categories

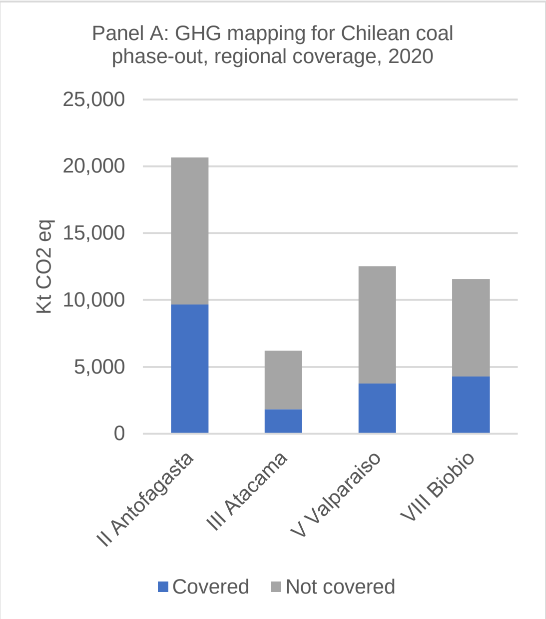
75. Figure 13 presents preliminary results for the GHG mapping of the coal-fired plant phase-out for Chile. It reveals that the phase-out covers about 19 $MtCO_2eq$, or nearly 19% of national GHG emissions. When assigning these emissions to IPCC emission source sectors, it is observed that they all fall within a single sub-sector (i.e. energy industries). The phase-out covers around 66% of this sub-sector’s total GHG emissions. Similarly, when assigning emissions based on the ISIC classification, they all occur within a single sector (i.e. electricity, gas, steam and air conditioning supply). However, it is challenging to determine the share of this sub-sector’s emissions covered by the phase-out, as the total emissions of this sub-sector are not readily available. It is also possible for the mapping exercise to produce insights at the regional (Figure 14A) and household levels (Figure 14B).

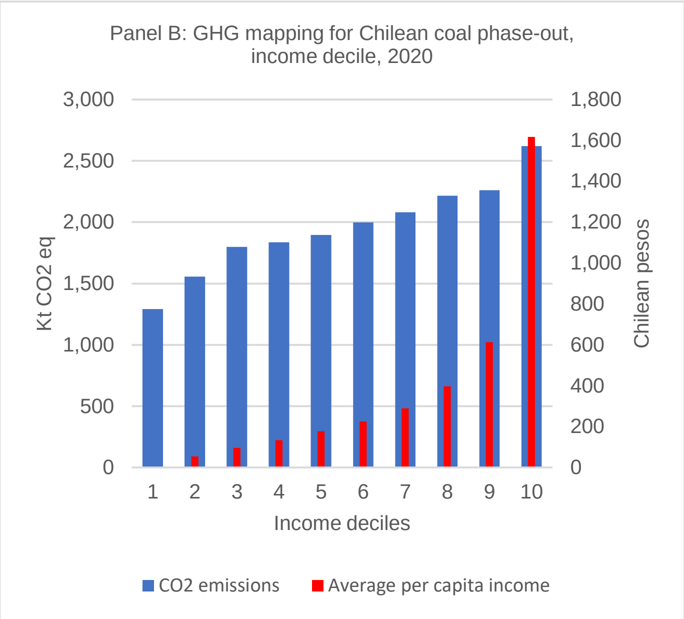
Figure 13. GHG mapping of the Chilean coal phase-out



Note: Preliminary results. Estimates based on MRV data from the Chilean Ministry of Environment, dating to 2022.
Source: Authors.

Figure 14. GHG mapping of the Chilean coal phase-out





Note: Preliminary results. Estimates based on MRV data from the Chilean Ministry of Environment, dating to 2022. Panel B compares income deciles (in red) with CO_2 emissions calculated based on a weighted average of the electricity consumption and linearly mapping to CO_2 emissions. Regional emissions exclude LULUCF.
Source: Authors.

4.3. A final note on these examples

76. These examples provide real cases of how to map GHG emissions to different policy instruments. As noted above, the GHG mapping will depend on the regulatory base, instrument design and the assets covered. Example 1 showed that the Chilean carbon tax covers around 30% of Chile's total GHG emissions, while the phase-out of coal-fired thermal electrical plants in example 2 covers only 19%. However, the potential impact of these policy instruments can be quite different. A priori, in the case of example 1, policy intensity or stringency is quite low with a tax rate of only USD 5 per tonne of CO_2, while in example 2, policy intensity is very high establishing a ban for 2040.

77. However, the GHG mapping only identified the instrument's GHG emission coverage. The final impact will depend on several additional factors that can only be assessed using modelling techniques and with additional information and assumptions. For example, the impact of the carbon tax of USD 5/tCO_2 will depend on how prices are affected, whether alternative fuel sources are available and competitive, on substitution effects, on the signalling effect for future investments, and other factors. Similarly, although the ban in the case of example 2 seems more stringent, the final impact will depend on enforcement capacity, and the investment in alternative electricity generation capacity to cover the shortfall.

78. In sum, GHG mapping is a necessary but not sufficient condition to support the analysis of the effectiveness of climate change policy action.

References

Flachenecker, F., E. Guidetti and P. Pionnier (2018), *Towards global SEEA Air Emission Accounts: Description and evaluation of the OECD methodology to estimate SEEA Air emission Accounts for CO2, CH4, and N2O in Annex-I countries to the UNFCCC*, https://doi.org/10.1787/7d88dfdd-en. [5]

IFCMA (2024, forthcoming), "Stocktaking and Greenhouse Gas Mapping of Transport Policy Instruments", *IFCMA Working Papers*. [7]

Nachtigall, D. et al. (2022), "The climate actions and policies measurement framework: A structured and harmonised climate policy database to monitor countries' mitigation action", *OECD Environment Working Papers*, No. 203, OECD Publishing, Paris, https://doi.org/10.1787/2caa60ce-en. [1]

OECD (2022), *OECD Economic Outlook*, https://www.oecd.org/economic-outlook/november-2022/. [6]

OECD (2022), *Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, https://doi.org/10.1787/e9778969-en. [2]

Sakata, S., A. Aklilu and R. Pizarro (2024), "Greenhouse gas emissions data: Concepts and data availability", *OECD Statistics Working Papers*, No. 2024/03, OECD Publishing, Paris, https://doi.org/10.1787/b3e6c074-en. [3]

United Nations (2008), *International Standard Industrial Classification of All Economic Activities (ISIC), Rev.4*, https://doi.org/10.18356/8722852c-en. [4]

Annex A. Glossary

Concept	Definition/ description
Climate change mitigation policy instruments	Policy instruments that are explicitly designed to reduce GHG emissions.
Climate change mitigation-relevant policy instruments	Policy instruments that have a substantive mitigation effect or potential without having mitigation as an explicit goal.
Emission-relevant assets	Assets that can generate or reduce emissions, directly or through the substitution of another asset. Depending on how the policy instrument is designed, they may coincide with the regulated assets. There are different types of emission-relevant assets: • **GHG-emitting assets** which generate emissions (e.g., thermal power plants, farming animals) • **Low-GHG emitting or GHG-removing assets which** generate low, no or negative emissions through their use, or that remove emissions (e.g., electric cars, solar panels) • **Enabling assets** whose diffusion can (or reduce) the adoption of low-GHG or restrict (or promote) the use of high-emitting assets (e.g., EV charging stations; dedicated EV parking spaces)
Emission base (or relevant emission base)	Refers to the total GHG emissions the policy instrument targets or potentially affects. It is defined by the policy instrument's regulatory base and by the emission source which may or may not be within the regulatory base.
GHG emissions mapping	The practice of linking a policy instrument to the emission base to determine its emission coverage. It identifies the emissions that a policy instrument intentionally or unintentionally covers and classifies these emissions according to relevant categories. It allows to illustrate the extent to which an instrument can *potentially* affect emissions in a given sector.
Legal obligation	The legal responsibilities imposed on the regulated agents (such as paying a tax, meeting an emission standard, or adopting specific technologies).
Policy instrument	Tools through which governments influence, enforce, or guide behaviour with the aim of achieving specific societal goals. They can impact GHG emissions by altering production and consumption choices, for example by setting constraints or offering economic incentives).
Policy regulatory base	The combination of agents, activities, and assets that are regulated by a policy instrument. They are always defined in an instrument's regulatory framework. The regulatory base determines the exact scope of the policy instrument, including who precisely has the legal obligation defined in the legislation.
Regulated agent	The legal entity (person or institution) regulated by the policy instrument, as defined in the instrument's regulatory framework. The regulated **agent** is required to fulfil the legal

	obligation and can be held accountable for non-compliance. They are not always explicitly defined in the regulatory framework but, in such cases, can be derived from the regulated asset and/or activity.
Regulated activity	The action or activity which is carried out by the regulated agent. It is usually the object of the legal obligation established in the regulatory framework and carried out by the regulated entity.
Regulated asset	The physical object that is regulated. It can be a structure (e.g. boilers and turbines), a fuel (e.g. coal or gas) or can be more generic such as products and inputs.
Regulatory emission base	The GHG emissions generated by the regulatory base.
Regulatory framework	Relates to the rules and regulations established by government agencies or regulatory bodies to oversee and govern specific industries, sectors, or activities. The regulatory framework defines the operational details of a policy instrument, e.g., who is regulated and how, how compliance is monitored and enforced, and other relevant administrative elements.

For more information:

www.oecd.org/climate-change/inclusive-forum-on-carbon-mitigation-approaches

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