Carbon Pricing Metrics:

Analyzing Existing Tools and Databases of Platform for Collaboration on Tax (PCT) Partners

PLATFORM FOR COLLABORATION ON TAX

OECD

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IFC International Finance Corporation

MIGA Multilateral Investment Guarantee Agency

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Acronyms

CCP	Comprehensive Carbon Price
CP	Carbon Pricing
DRM	Domestic Resource Mobilization
ECP	Emissions-weighted Carbon Price
ECR	Effective Carbon Rate
EGR	Emissions Gap Report
ETS	Emissions Trading System
EU	European Union
GDP	Gross Domestic Product
GJ	Gigajoules
IEA	International Energy Agency
IMF	International Monetary Fund
kWh	Kilowatt hours
LPG	Liquified Petroleum Gas
OECD	Organisation for Economic Co-operation and Development
PCT	Platform for Collaboration on Tax
RFF	Resources for the Future
SDG	Sustainable Development Goal
TCP	Total Carbon Price
TEU	Taxing Energy Use
TWG	Technical Working Group
UN	United Nations
UNDP	United Nations Development Program
USD	United States Dollars
VAT	Value-Added Tax
WB	World Bank
WBG	World Bank Group

1. Introduction

Carbon pricing (CP) is an economic and environmental policy strategy that places a monetary cost on the emission of carbon dioxide and other greenhouse gases. It is designed to internalize the external (social) costs of these emissions, such as the damage caused by climate change, air pollution, and the associated health impacts. As a tool in climate policy, carbon pricing aims to incentivize businesses, industries, and individuals to reduce their carbon emissions by making it financially beneficial to shift towards cleaner, more sustainable practices. This policy instrument can take various forms including carbon taxes, emissions trading schemes, or a combination of both. Despite its potential effectiveness and cost-efficiency in reducing greenhouse gas emissions, carbon pricing is not neutral in its impact across society and faces numerous challenges. These include political acceptability, international competitiveness concerns, potential impacts on low-income households, and the complexity of accurately pricing carbon in line with its true environmental cost. Implementation of carbon pricing also requires careful consideration of the specific economic, social, and environmental context of each region or country.

Over the last decade, international organizations have developed a wide range of metrics on carbon pricing and related policies. This paper focuses on elucidating the range of approaches and computation methods used to measure the carbon tax rate, or price signal, that are associated with implemented carbon pricing policies. Its purpose is to provide a wider methodological purview that can enhance public understanding of the state and trends of carbon pricing, including its progress against benchmarks. The methods described can help policymakers, businesses, and other stakeholders to make more informed decisions when designing, implementing, and reforming carbon pricing policies. The report does not prescribe any computation method over the others but provides a bird's eye view of the various available approaches.

This diversity of approaches provides a rich perspective on the different forms of carbon pricing: 'direct', 'indirect', 'positive', and 'negative'. However, it also risks confusing policymakers and other stakeholders. Metrics may differ in their instrument coverage or geographical scope. For example, while some of these metrics consider direct (also called explicit)

CP, others focus also on indirect CP (called implicit[1] prices). Additionally, metrics may differ in the methodology chosen. For instance, complementary ways of measuring subsidies include the price gap, inventory, and the effective tax[2] approach.

The aim of this paper is to facilitate comparison of the various metrics. This paper provides an overview of how various metrics complement each other and how they differ. It identifies unifying concepts behind different terminologies and provides insight into how the various forms of carbon pricing relate: direct, indirect, positive, and negative. Thus, it can inform pricing decisions such as removing fossil fuel subsidies alongside introducing carbon or fuel excise taxes, and it can improve policy coherence.

This paper showcases CP metrics focusing on the Partner Institutions of the Platform for Collaboration on Tax (PCT). The PCT is a joint initiative of the International Monetary Fund (IMF), the Organisation for Economic Co-operation and Development (OECD), the United Nations (UN), and the World Bank Group (WBG) to strengthen collaboration on resource mobilization (RM) through taxation. As part of these efforts, and according to their respective mandates, PCT Partners undertake analytical work to benefit the collective membership of their four organizations and to provide developing countries with clear, coherent, and practical tools to address a range of contemporary tax issues. This paper is embedded in the workstream on environmental taxation—a PCT priority area—and, while it explores the metrics of the PCT partner institutions, it also analyzes other CP metrics.

This paper describes a new typology for analyzing and understating CP metrics. The typology comprises two general components: what is measured (coverage and rate) and why it is measured (purpose and use). It can facilitate the analysis and comparison of metrics and benefit stakeholders by identifying the unifying concepts behind differing terminologies. Thus, it can facilitate discussions between different government branches (Ministries of Finance, Energy, and Environment) within countries.

1 This use of the term 'implicit' should not be confused with applications of the term that refer to the 'shadow price' on non-price policies.

2 The effective tax approach is a broader effort that attempts to capture the net incentive structure, or 'price-equivalent' signal, arising from a broader set of policies, including subsidies.

The proposed typology is employed to undertake a comparative analysis of CP metrics. The study finds that the existing metrics are complementary, and together they provide a comprehensive description of the CP landscape. Notably, the analysis highlights a key dimension of convergence: PCT Partners concur in considering both explicit and implicit (also called direct and indirect) metrics of carbon pricing.

PCT Partners concur on a crucial message: Energy prices are poorly aligned with climate, environmental, and health costs. Strategies to tackle the price misalignment include the removal of fossil fuel subsidies, higher carbon prices via carbon taxes or emissions trading systems (ETS), and better alignment of fuel taxes with climate (and domestic) costs. The four PCT Partners concur on the perspective that carbon pricing can take many forms, including excise taxes that effectively set a price on carbon or subsidies that undermine explicit carbon prices.

Lastly, this exercise identifies knowledge gaps and highlights potential further joint or individual focus areas. For example, low and high carbon-intensive goods face, on average, different trade tariffs (Shapiro, 2020). Studying whether this tariff differential represents a carbon subsidy can be an exciting new area for future research. In addition, other fiscal policies not discussed in this paper can effectively create positive or negative prices on carbon. For instance, subsidies (or taxes) on deforestation-driving commodities can affect the absolute and relative prices of these goods in ways that are not aligned with their greenhouse gas (GHG) emissions contribution.

This paper is organized as follows. After this section, section 2 describes the metrics of the PCT Partners to CP. Section 3 suggests a framework to compare different CP metrics. Section 4 proposes a new typology to compare metrics, and then analyzes and compares the CP metrics. Section 5 compares CP metrics based on technical considerations. Section 6 uses country examples to illustrate messages that are common across PCT Partners. This section exemplifies how countries can use this typology and complementary information from different metrics to assess their own carbon pricing levels better. Section 7 provides concluding remarks.

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2. The international Carbon Pricing (CP) landscape: metrics, datasets, and publications

Over the last decade, a wide array of CP metrics, definitions, and metrics have been developed by the PCT Partners and other academic and civil society institutions. For example, in 2013, the OECD introduced *"Taxing Energy Use"* (TEU), a publication series reporting on tax-based carbon prices. In 2016, the OECD started tracking *Effective Carbon Rates (ECR),* which report on the total price of carbon emissions resulting from taxes (carbon and fuel taxes) and compliance with emissions trading markets. Besides positive carbon prices, the OECD tracks subsidies employing an inventory-based approach, which dates to 2012. The International Energy Agency (IEA) produces estimates of fossil fuel subsidies using the price gap approach (comparing prices on international markets against prices paid by domestic consumers). In that sense, the OECD and the IEA produce complementary databases of government support for fossil fuels—with the OECD focusing on an inventory approach of budgetary transfers and tax breaks and the IEA on fossil fuel subsidies measured by the price-gap approach. A combined OECD-IEA dataset on these two complementary databases covers 51 major economies (OECD-IEA, 2022). The IMF also tracks subsidies. In a series of fossil fuel subsidy publications, the IMF measures and tracks the efficient fossil fuel prices (see section 2.1) and subsidies implied by charging fossil fuel prices below efficient fuel prices. The World Bank tracks the global and country-level developments of explicit carbon prices (emissions trading and carbon taxes) in its flagship yearly publication, State and Trends of Carbon Pricing. The UN has also contributed to better measurement and implementation of carbon pricing. In 2021, the UN published the *United Nations Handbook on Carbon Taxation for Developing Countries* providing practical guidance on policy considerations and administrative issues related to carbon taxes. In addition, the *Emissions Gap Report* (EGR) 2021, published by UNEP, emphasizes the role of market mechanisms—including carbon taxes and emissions trading systems—as an important component of strategies to achieve the goals of the Paris Agreement. The UN has also contributed to a better measurement of fossil fuel subsidies. The UN's flagship report on *Measuring Fossil-Fuel Subsidies in the context of SDGs* provides a methodology that countries can apply to measure subsidies. In addition, the EGR stresses the role of limiting fossil fuel subsidies in accelerating a green recovery.

The metrics that have been developed differ in terms of policy coverage (such as taxes, emissions trading, subsidies, etc.) and country coverage. This section describes the metrics, databases, and approaches of each of the four PCT Partners in detail. A summary is provided in Table 1 below.

Table 1. Summary of existing approaches: Publications, metrics, and datasets

Institution	Approaches: Publications and metrics	Dataset
OECD	Effective Carbon Rates (ECR) and Taxing Energy Use (TEU)	Effective Carbon Rates
	Inventory of Support Measures for Fossil Fuels	Fossil Fuel Support Data
IMF	Fossil Fuel Subsidies	IMF fossil fuel subsidies dataset
	Climate Change Indicators	Climate Change Indicators Dashboard
World Bank	State and Trends of Carbon Pricing	Carbon Pricing Dashboard
	Energy Subsidy Reform Assessment Framework (ESRAF)	N/A
UN	UN Handbook on Carbon Taxation for Developing Countries	N/A
	• Measuring Fossil-Fuel Subsidies in the context of SDGs (UNEP-IISD) • Emissions Gap Report (EGR), 2021	N/A
OECD, IMF, IEA	Fossil Fuel Subsidy Tracker	Fossil Fuel Subsidy Tracker
IEA	IEA Energy Subsidies	IEA Energy Subsidies Database
RFF	Emissions-weighted carbon price or ECP (Dolphin et al. 2020, Dolphin, 2022)	Emissions Weighted Carbon price dashboard
Vivideconomics & ODI	Estimating effective carbon prices	N/A
Other	• Comprehensive carbon price or CCP (Carhart et al., 2022) • The environmental bias of trade policy (Shapiro, 2020)	• Kepos Carbon Barometer • N/A

Source: Authors.

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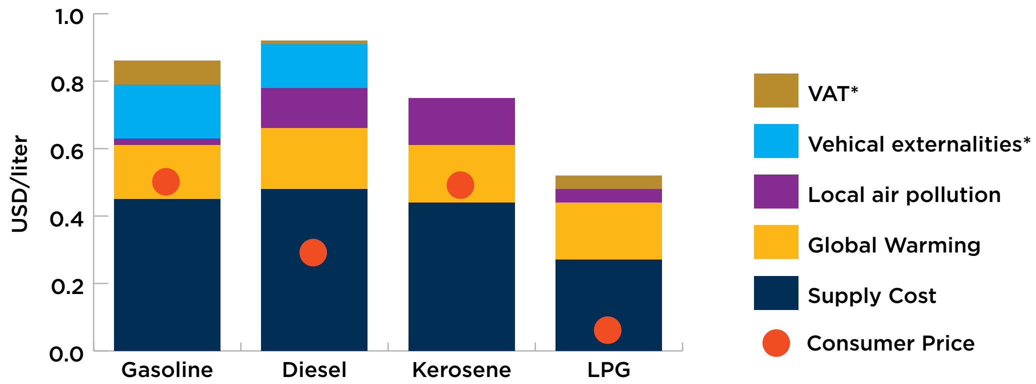
2.1 IMF

The IMF's approach includes a series of reports on setting efficient energy prices and measuring the subsidies that are implied when prices are set below their efficient level (Parry et al., 2014, 2021b; Coady et al., 2015, 2019). The IMF puts forward a methodology to understand efficient energy prices, defining, and estimating: 1) the efficient fossil fuel prices as those that reflect all supply and environmental costs, and where applicable, general taxes applied to consumer goods; 2) implicit subsidies whenever there is undercharging for environmental costs, and 3) explicit subsidies whenever retail prices are below supply costs. For example, when the consumer price is below the supply cost (after accounting for VAT), there is an explicit subsidy. This is illustrated in Figure 1, where the consumer prices for diesel and LPG are below the supply costs. Instead, an implicit subsidy refers to the extent by which the consumer price falls short of incorporating all supply and environmental costs (the difference between the consumer price and the externality components). As illustrated in Figure 1, the implicit subsidy is generally larger than the explicit subsidy. Using these definitions, the IMF estimates subsidies and fuel taxes for over 191 countries.

IMF reports are published alongside a dataset that covers 191 countries and is broken down by sector and fuel (see Table 2). According to Parry et al., (2021b) underpricing of fossil fuels is still pervasive, with global fossil fuel subsidies totaling USD 5.9 trillion in 2020; with 92% corresponding to implicit subsidies (undercharging for environmental costs and forgone consumption taxes), and the rest (8%) reflecting explicit subsidies (undercharging for supply costs). The largest price gaps (or underpricing) are generally for coal, followed by natural gas, diesel, and gasoline (see Figure 2).

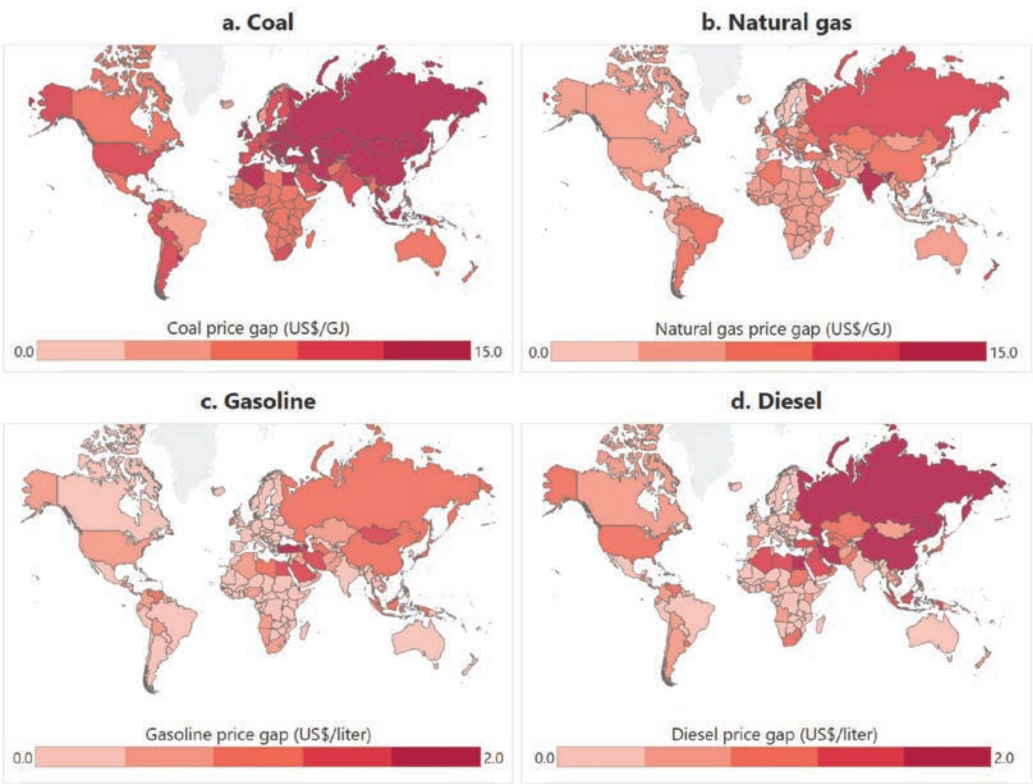
In 2022, the IMF launched the "Climate Change Indicators Dashboard," which gathers indicators that demonstrate how global economic activity affects the climate and the actions that governments are taking to mitigate those impacts. The indicators are grouped into: Economic Activity, Cross-Border, Financial and Risk, Government Policy, and Climate Change Data.

Figure 1. IMF calculation of implicit and explicit subsidies: Ecuador (2020)



*Weighted by share of consumption relevant to the externality (e.g. VAT is only applied to final consumption)
Source: Parry et al., 2021

Figure 2. Gap between efficient prices and user prices for fossil fuels by country (2020)



Source: Parry et al., 2021

2.2 OECD

The OECD publishes two major reports on carbon pricing: Taxing Energy Use (TEU) and Effective Carbon Rates (ECR), which have recently been combined in a new OECD Series on Carbon Pricing and Energy Taxation. Traditionally, the TEU publication series focused on tax-based carbon prices and energy price signals, providing a breakdown of tax rates (net of exemptions, rate reductions, and refunds), as well as tax base by country, sector, energy source, and tax type. It was first published in 2013 focusing on OECD countries (OECD, 2013). In 2015, it extended its scope to include G20 countries (OECD, 2015). By 2019, it covered 44 OECD and G20 countries. The 2019 TEU report found that 70% of energy-related CO_2 emissions are not taxed, implying considerable opportunities to advance CO_2 pricing. These opportunities to advance taxation are mainly outside the transportation sector, where 82% of emissions are still taxed at zero rates (OECD, 2019).

The ECR publication series broadened the scope of the carbon pricing covered in TEU by including emissions trading systems. In that sense, it provides a comprehensive approach (see Figure 3) that integrates carbon prices resulting from taxes and emissions trading systems (OECD, 2021b). The publication, and the database linked to it, define ECR as the total price of emissions[3] resulting from taxes (carbon and fuel taxes) and compliance with emissions trading markets, using a methodology to calculate coverage that considers overlapping policies.[4] In addition to defining the ECR for every unit of emissions in a country, the OECD provides country- and sector-level summary indicators, such as an emissions-weighted average ECR (OECD, 2018b).

The Net Effective Carbon rate (Net ECR) is a new metric that deducts fossil fuel subsidies from the ECR (OECD, 2022). In other words, it consists of the sum of explicit carbon prices and fuel excise taxes, minus fossil fuel subsidies. Table 2 summarizes the main difference in coverage between the Net ECR, the ECR and the TEU.

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3 The TEU accounts for tax reductions and refunds. However, the ECRs (2016-2021) did not include pre-tax fossil fuel subsidies. Pre-tax fossil fuel support has been integrated in the Effective Carbon Rate metric for the first time in the Taxing Energy Use for Sustainable Development (OECD, 2021d). The 2022 Net ECR mainstreams this approach to 71 countries included in the new 2022 report that integrates TEU and ECR (OECD, 2022).

4 See Annex A in OECD (2016b) for more information on how the overlap is taken into consideration in different sectors. Price signals to date are insufficient, even when extending the scope of carbon pricing to include emissions trading systems.

Figure 3. The Effective Carbon Rate and its components

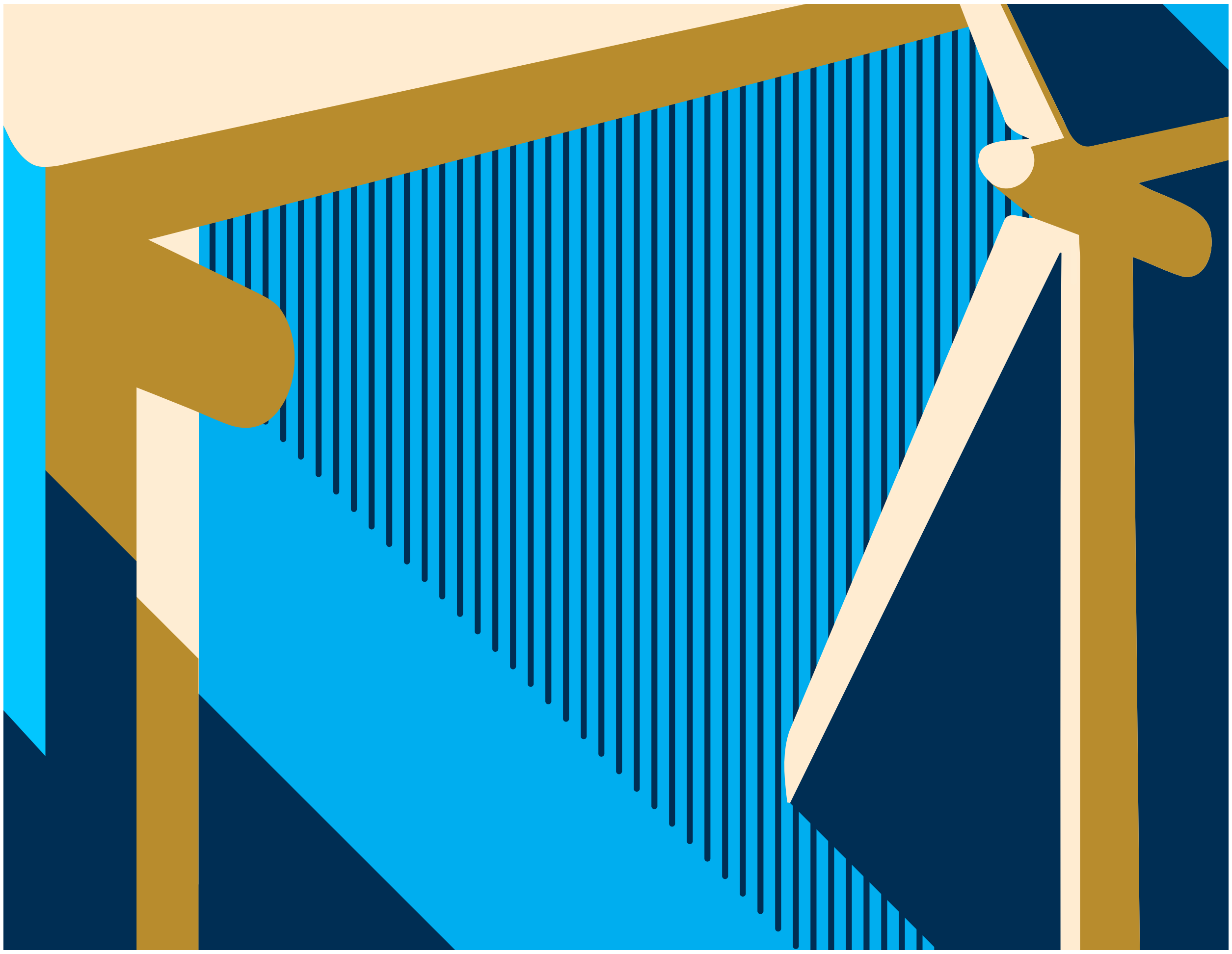
Source: OECD, 2021

The ECR supports the main key takeaway of the TEU, namely, that carbon price signals to date are insufficient even when extending the scope of carbon pricing to include emissions trading systems. According to the ECR (2021), around 60% of CO_2 emissions from energy use in OECD and G20 countries remained unpriced in 2018 (OECD, 2021b). The scope of TEU and ECR was expanded in 2022 to cover subsidies that lower pre-tax energy prices and several other developing countries, as well as all GHG (expanding the focus beyond CO_2 emissions from energy use) (OECD, 2022).

In addition to reporting on positive carbon pricing, the OECD employs an inventory-based approach to report on other forms of support measures (OECD, 2013c, 2015c, 2018c, 2021c). Since 2012, the Inventory of Support Measures for Fossil Fuels tracks government budgetary transfers and tax expenditures that provide preferential treatment for the production and consumption of fossil fuels in 50 OECD, G20, and European Union Eastern Partnership countries (OECD, 2021c).

Tax expenditures in the Inventory are measured by the amount of tax reduction provided relative to the benchmark tax treatment that would otherwise apply. For example, a country with a tax expenditure on diesel may set a benchmark tax rate of 20 cents per liter of diesel, but a 10 cents per liter rate for diesel used in the agricultural sector. Tax expenditures represent revenue forgone, and from an environmental perspective, they can change relative prices of fuels or fuel uses across sectors. In other words, although fuel use with tax reduction faces a lower carbon price than it would with the benchmark rate, it continues to face a carbon price. Finally, tax expenditures are not comparable across countries because the benchmark tax treatment varies from country to country (TEU, 2013). Instead, tax rates can be compared against a uniform carbon pricing benchmark, such as EUR 60 per ton of CO_2. This is an approach that the OECD has used in the ECR and TEU to calculate the share of emissions priced at different benchmark levels.

Direct budgetary transfers refer to payments made by governments, or bodies acting on behalf of governments, to individual recipients. This includes direct spending, such as for specific support programs, as well as government ownership (either entirely or through equity shares) of energy-related enterprises. For example, a country that subsidizes electricity prices to consumers via direct budgetary transfers to a national electricity operator.



2.3 WBG

The State and Trends of Carbon Pricing is the World Bank's flagship CP report, which has traditionally focused on explicit (direct) carbon pricing (World Bank, 2014, 2021). Since 2014, the World Bank reports the progress of CO_2e prices and coverage of carbon taxes and emissions trading systems implemented worldwide, including regional,[5] national and subnational initiatives (see Table 2). In addition, it provides an overview of the instruments scheduled or under consideration. The main added value of the report is data compilation from primary sources via government agencies, as well as the methodology to calculate the proportion of global emissions covered by a carbon price, which includes estimating the overlap across carbon pricing policies (World Bank, 2014) (see Figure 4).

Each year, the State and Trends of Carbon Pricing report discusses emerging pricing trends, highlights, and key lessons from the growing carbon pricing experience (World Bank, 2014). For instance, in 2015 it featured a chapter on carbon leakage (World Bank, 2015), while in 2016 it included a chapter on building an international carbon market after Paris (World Bank, 2016). Additionally, the report covers the developments of carbon crediting mechanisms, including those governed by international climate treaties and those independent of the latter.

Since 2019,[6] WB's State and Trends of Carbon Pricing report has started to consider incentives beyond explicit (direct) CP. This represents a move toward a more comprehensive approach to carbon pricing. According to the report: "Many countries are already implicitly pricing carbon through other policies, such as fuel taxes or fuel subsidies reforms. Taking this wider view will allow for a transparent view of the total price applied to carbon emissions, to utilize a wider portfolio of instruments to drive climate action, and to strengthen the ability to overcome implementation challenges" (World Bank, 2019). However, the report does not report on implicit or indirect prices or coverage.

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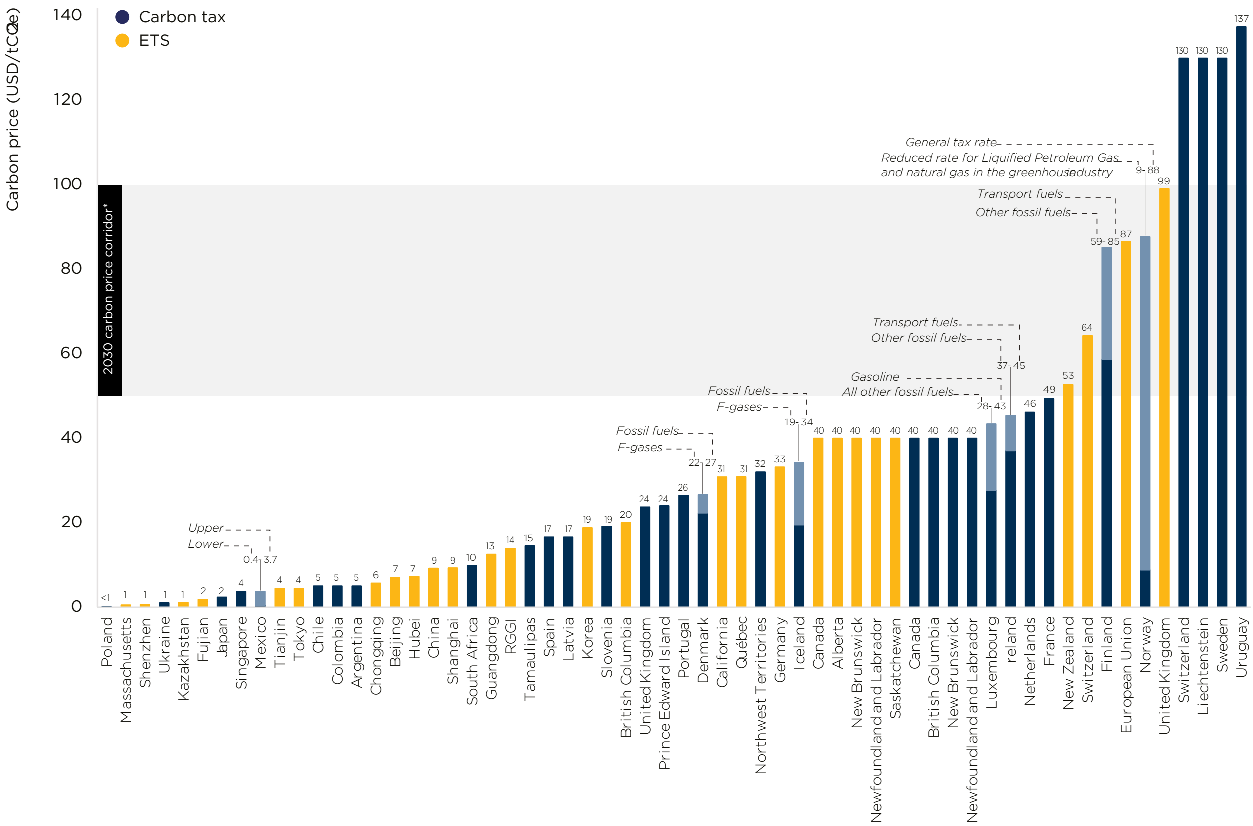
5 For example, the EU ETS.

6 In 2019, the State and Trends of Carbon Pricing report first started considering 'implicit' carbon prices. In 2021, it featured a section on implicit carbon pricing. The 2022 report changed the terminology used from 'implicit' to 'indirect' carbon pricing.

Figure 4. Direct carbon prices by carbon pricing instrument (USD/tCO_2e in 2022)



Nominal prices on April 1, 2022 are shown for illustrative purpose only. Prices are not necessarily comparable between CPIs because of (for example) differences in the sectors covered and allocation methods applied, specific exemptions, and compensation methods.

* The 2030 carbon price corridor is based on the recommendations in the report of the High-Level Commission on Carbon Prices.

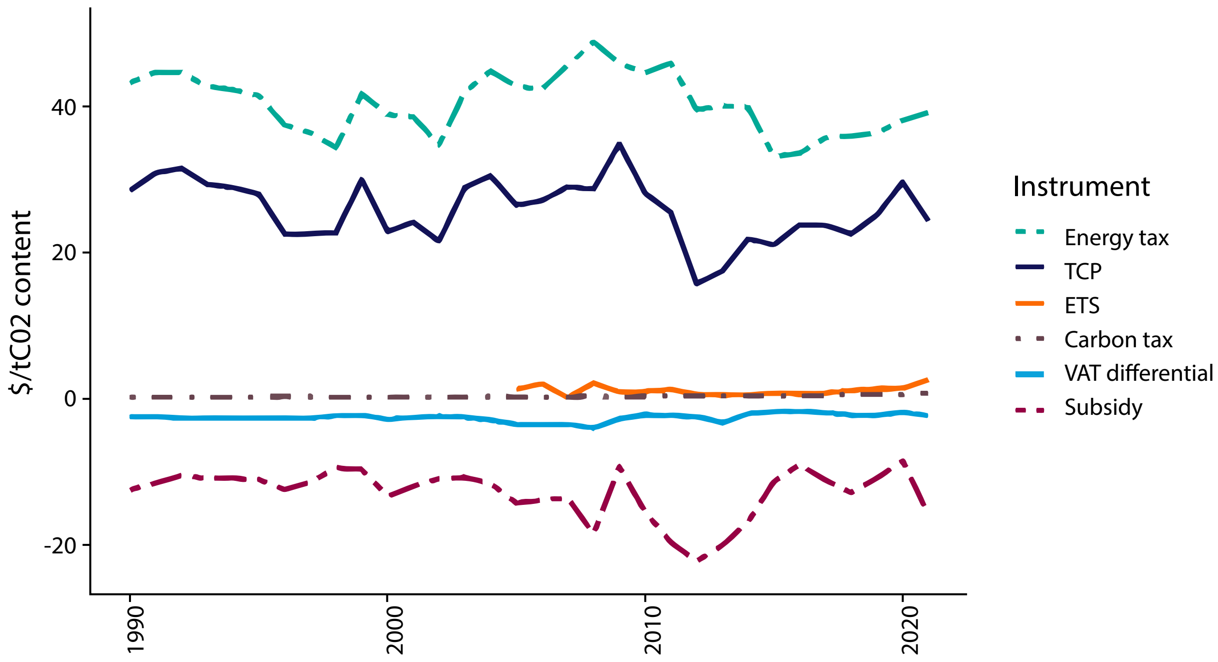
** Several jurisdictions apply different carbon tax rates to different sectors or fuels. In these cases, we have indicated the range of tax rates applied, with the dark blue shading showing the lower rate and the combined dark blue and light blue shading representing the higher rate.

Source: World Bank (2022)

The Carbon Pricing Dashboard was launched in 2017 as an interactive online tool for visualization and data download. While the State and Trends of Carbon Pricing report focuses on recent (previous year) developments, the Dashboard collects all explicit pricing and coverage data from 1990 (see Table 2).

Recent work carried out by World Bank staff proposes a new methodology to measure the total carbon price (Agnolucci et al., 2023). This metric will capture the full (direct and indirect) and net (positive minus negative) carbon price signals affecting fossil fuel consumption and associated emissions. The total carbon price can be obtained for each fuel, sector, and the whole economy. Agnolucci et al. (forthcoming) find that the total carbon price at the global level shows stalled progress over the last 30 years (see Figure 5). This does not necessarily mean that carbon pricing instruments have had little tangible effect on emissions within the jurisdictions that have implemented them. It does mean, however, that future econometric research should evaluate the elasticity of emissions with respect to the total carbon price level, rather than just the nominal price, to get a clearer understanding of the overall impact.

Figure 5. Total Carbon Pricing and its components



Source: Agnolucci et al. (forthcoming)

The work of the World Bank on subsidies includes the creation of the Energy Subsidy Reform Assessment Framework (ESRAF) to help governments achieve socially sustainable energy subsidy reforms. ESRAF is a guide for country reform, and in that sense, it does not provide a metric or specific approach to measure subsidies. ESRAF provides notes on how to categorize and measure subsidies (ESMAP, 2017).

2.4 UN

The UN *Handbook on Carbon Taxation* provides practical guidance on policy and administrative aspects of designing and implementing carbon taxes. It was developed by the UN Committee of Experts on International Cooperation in Tax Matters[7] and its Subcommittee on Environmental Taxation Issues. The Handbook provides practical guidance for countries that have or are considering introducing a carbon tax. It covers various crucial aspects, including the design of a carbon tax, revenue use, acceptability and other administrative aspects, with real-world examples and practical tools. It supports countries in aligning their fiscal policies with the commitments of the 2030 Agenda and the Paris Agreement.

The Handbook guides policymakers on several aspects of carbon tax design and implementation, including:

1. How to ensure public acceptability.
2. Design aspects of a carbon tax.
3. How to address undesired effects of the carbon tax.
4. A discussion of the administrative issues.
5. The complexities surrounding revenue uses, and the interactions between carbon taxes and other instruments.

7 During its 15th Session, the Committee established the Subcommittee on Environmental Taxation Issues with the "mandate to consider, report on and propose guidance on environmental tax issues and opportunities for developing countries" (UN, 2021).

The Handbook provides a series of checklists for policymakers. For example, for determining the tax rate trajectory, as shown in Figure 6.

Figure 6. UN Checklist for determining the carbon tax rate trajectory

1. **Fixed Tax Rate**
2. **Dynamic Tax Rate**
   - (i) Predetermined Adjustment
     - (a) Ramp-up strategy
     - (b) Based on national conditions, e.g., inflation indexed
     - (c) Based on external conditions, e.g., trading partners
   - (ii) Flexible
     - (a) Based on revaluation and assessment of policy objectives, such as emission targets
     - (b) Based on technical committed evaluation
3. **Tax Rate Considering Economic Conditions**
   - (i) Adjustments based on economic strategy, e.g., green growth strategy
   - (ii) Adjustment considering economic crisis, e.g., COVID-19 emergency

The UN Handbook discusses the role of fuel taxes as part of an aggregated carbon price. According to the Handbook: "It is also important to note that there are several other instruments that a country may introduce, or already have in place, which in practice sets a price on carbon, for example, taxes on energy, excise taxes on fossil fuels, resource taxes, among others" (UN, 2021, pp. 21). On the role of an aggregated price signal on carbon emissions, the UN Handbook notes: "Considering other market instruments in the analysis can contribute to the aggregated price signal on carbon emissions in each jurisdiction and therefore provide a broader context. In this respect, specific taxes on fuel (excise taxes) can also be relevant to consider in a benchmarking analysis, as well as prices observed in emissions trading systems. Although they do not explicitly price carbon, excise taxes on fuels mirror carbon taxes and can support the benchmark analysis" (UN, 2021, pp. 70). Consistently, other UN reports note that fuel taxes effectively place a price on carbon. For instance, the 2021 Financing for Sustainable Development Report (FSDR) states that:

"The two main explicit carbon pricing mechanisms are a carbon tax and an emissions trading scheme (ETS). A carbon tax is arguably the more powerful measure for mitigating climate change. Fuel taxes also effectively result in a carbon price" (UN, 2021c, pp. 45).

However, the UN also highlights the need to align fuel taxes with their carbon content. The FSDR notes: "Fuel excise taxes, which also discourage the use of fuels and the associated emissions, are increasingly scrutinized to improve their alignment with carbon content" (UN, 2021c, pp. 45).

Like other PCT Partners, the UN has contributed to a better understanding of the role of subsidies. The UN's flagship report on Measuring Fossil-Fuel Subsidies in the context of SDGs (UNEP-IISD, 2019) introduces a metric to be used by countries in their own subsidy measurements. It recommends the measurement of three sub-indicators: 1) direct transfers of government funds, 2) induced transfers, and 3) tax expenditures, other revenue forgone and underpricing of goods and services. However, sub-indicator 2 remains an optional recommendation.

The role of subsidies and the need for subsidy reform to align incentives is also discussed in the UN Handbook. For instance, in Chapter 9 on revenue uses, the Handbook notes: "In countries that do not use coal, tax and subsidy reform will provide incentives for skipping the coal phase in electricity generation and industry" (UN, 2021, pp. 166-167). It further mentions the role of subsidies in undermining the goals of a carbon tax: "When considering introducing a carbon tax, it is crucial to determine the policies or instruments that subsidize and encourage carbon emissions, both at the consumption and production levels. The co-existence of such subsidies or incentives, together with carbon pricing, needs to be evaluated by the country's policymakers to avoid undermining the effectiveness of the carbon pricing policy, as well as its public acceptability" (UN, 2021, pp. 174).

Several UN high-level reports weigh in on the role of fossil fuel subsidies in undermining decarbonization goals, strategies, and policies. For instance, the UN 2021 Report on Sustainable Development (UN, 2021b, pp. 50) notes that: "G20 countries continue to provide unconditional fossil fuel subsidies in COVID-19 recovery packages, exceeding USD 50 per capita in eight of the G20 countries as of April 2021." The 2021 Financing for Sustainable Development Report (FSDR) notes that the removal of subsidies is part of a smart policy mix: "investment alone will not suffice and successful climate mitigation and adaptation require a combination of policies: carbon pricing, elimination of fossil fuel subsidies, a sustainable investment push, and support for green energy research and innovation" (UN, 2021c, pp. 2). The FSDR, adds that: "To date, such subsidies remain large and contribute to the massive underpricing of the true production and environmental costs of fossil fuels—leading to higher global carbon emissions, more fossil fuel air pollution deaths and decreased government revenues" (UN, 2021c, pp. 10). Finally, the third installment of Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report notes the expected impacts of their removal: "fossil fuel subsidy removal is projected by various studies to reduce global CO_2 emissions by 1-4%, and GHG emission by up to 10% by 2040, varying across regions (medium confidence)" (IPCC, 2022, pp. 60). Finally, the UN EGR is an annual report series that provides an overview of the gap between where GHG emissions are expected to be in 2030 and where they should be to avoid the worst of climate change. The EGR stresses the role of market mechanisms, including carbon taxes, emissions trading, as well as subsidy removal in bridging the emissions gap (see the market mechanisms factsheet associated with the 2021 report). (UNEP, 2021)

2.5 IEA

The IEA's approach to measuring subsidies follows the price-gap approach. The IEA publishes a consumption subsidies dataset disaggregated by year, country, and fuel for 42 non-OECD countries. The IEA's estimates do not capture subsidized research or subsidies for fossil fuel production. In that sense, the estimates understate total fossil-fuel subsidies. The purpose of this data is to undertake a comparative analysis to support policy development. A combined OECD-IEA dataset finds that overall government support for fossil fuels in 51 countries worldwide almost doubled from 362.4 USD billion in 2020 to 697.2 USD billion in 2021. (OECD-IEA, 2022).

2.6 Other metrics

Other metrics have emerged in different institutional settings. For example, in 2019, Vivideconomics and ODI published a report on how to estimate effective carbon prices. The report aims to provide a clear metric linking the phasing out of fossil-fuel subsidies to carbon pricing by providing two complementary approaches: the *total incentive revenue* and *total incentive price.* The revenue approach estimates the net fiscal stance towards high-carbon compared to low-carbon technologies. In contrast, the price approach identifies the total set of incentives provided by policies that alter energy prices. The price approach extends OECD's ECR approach by incorporating the net price uplift from other energy policies as well as energy subsidies with price impacts.

Efforts in a similar direction include the Comprehensive Carbon Prices (CCP) metric proposed by Carhart et al., (2022). The CCP consists of a weighted average of marginal incentives imposed on polluters by country policy mixes. Seven types of market-based policies are included: carbon taxes, emissions trading systems, fossil fuel taxes, fossil fuel subsidies, renewable portfolio standards, feed-in tariffs, and low-carbon fuel standards. The threshold criterion to include a policy is whether it provides (1) a marginal incentive to reduce CO_2 emissions, and (2) involves an observable price component, either directly or by creating a market-based tradable instrument that indirectly reveals a price. The paper provides country-level CCP from 2008 to 2019 on 25 high-polluting countries representing 82% of global CO_2 emissions.

Finally, the Emissions-weighted Carbon Price (ECP) proposed by Dolphin et al., (2020) consists of the average explicit carbon price (ETS and carbon taxes) applied to CO_2 emissions across all sources of emissions within a territorial jurisdiction. The paper provides a methodology to calculate coverage considering overlapping policies.

Table 2. **PCT Partners' carbon pricing metrics and databases: Instrument and period coverage**

Partner	Database/ publication	Metrics	Instruments covered	Data available	Level of disaggregation
OECD	ECR	ECR	ETS, carbon taxes, fuel taxes, ex-post fossil	2012, 2015, 2018, 2021	Fuel and sector, by country
	Pricing Greenhouse Gas Emissions (OECD)	Net ECR	ETS, carbon taxes, fuel taxes, pre-tax fossil fuel subsidies	2018, 2021	Fuel and sector, by country
	TEU		Energy taxes, carbon taxes and ETS (since 2018)	2012 2015, 2018, 2021	Fuel and sector, by country
IMF	Fossil fuel subsidies	Explicit and implicit subsidies	Explicit and implicit subsidies, carbon taxes, energy taxes, and ETS	1990-2021	Fuel and sector, by country
WB	Carbon pricing dashboard	Carbon rate levels and coverage	ETS, carbon taxes	1990-2021	Jurisdiction level
UN	UN Handbook on Carbon Taxation for Developing Countries	The Handbook does not include metrics but does include practical guidance on how to implement carbon taxes.	Carbon taxes	—	Jurisdiction level

Source: Authors.

3. Framework to understand and analyze carbon pricing metrics

The carbon pricing metrics and reports described above use different terminologies and complementary methods, and cover different types of policies. Yet, features that a priori seem to diverge, have unifying concepts. This section proposes a framework for analyzing CP metrics systematically.

The framework comprises two categories: what is measured (coverage and rate/form) and why it is measured (purpose and use) (See Figure 7). Coverage refers here to the categories of policies tracked by a metric, including price-based policies (e.g., carbon taxes and ETS), non-price-based policies (e.g., regulations), and trade policies (e.g., tariff differentials between low-carbon and high-carbon imports). Carbon pricing can come in different forms, including positive, negative, indirect/or direct. For instance, pre-tax fossil fuel subsidies create a negative carbon price (World Bank, 2021, Vivideconomics & ODI, 2019, OECD, 2021d), while carbon taxes and ETS create a positive carbon price signal (World Bank, 2021, OECD, 2021). Metrics can also differ in their focus on indirect or direct (also called implicit and explicit) rates. For example, direct (explicit) carbon pricing is mainly delivered by carbon taxes and ETS via a price that is generally levied on GHG emissions or the carbon content of the fuels.[8] In contrast, indirect (implicit) carbon pricing refers to instruments that change the absolute and relative prices of products associated with carbon emissions in ways that are not perfectly aligned with GHG emissions and/or with the carbon content of the fuels.[9] Indirect carbon pricing is delivered, for instance, via fuel taxes levied in terms of physical units[10] (e.g. USD per

8 Fuel based carbon taxes may not always be levied in ways that are aligned with CO_2 emissions from fuel combustion or the carbon content of the fuel. In that sense, even explicit carbon taxes can vary considerably across fuels because of rate reductions or because they are applied to some fuels (e.g., Uruguay´s carbon tax applies exclusively to gasoline).

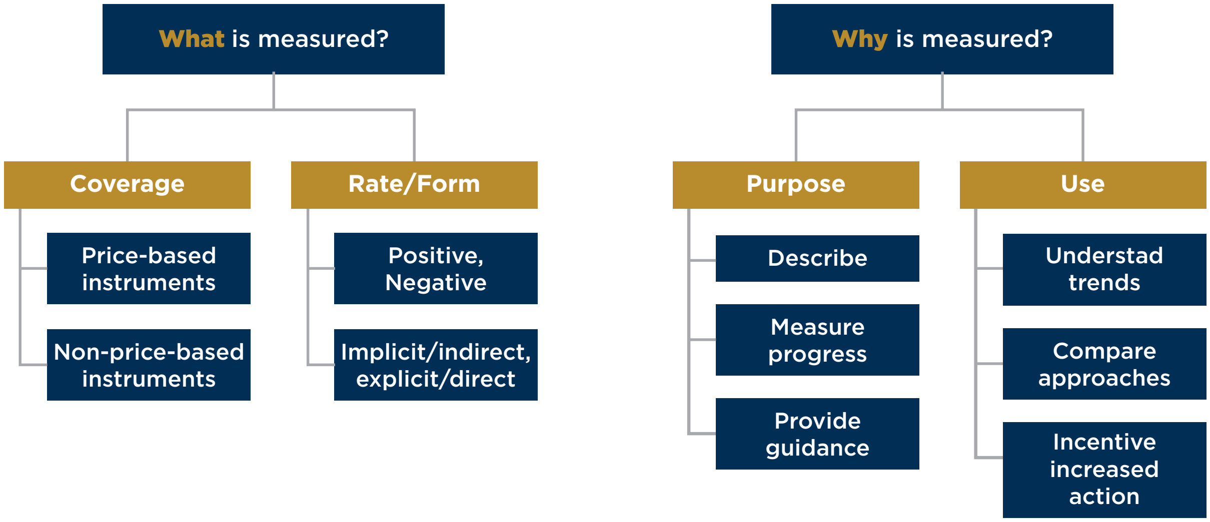
9 Note that, in practice, many explicit carbon prices also vary across users and sectors, albeit to a lesser extent than indirect carbon prices. This occurs, for instance, when a sector is not included as part of the regulated ETS sectors or when a fuel is zero-rated under a carbon tax regulation.

10 Note that fuel-based (also called upstream) carbon taxes can be administered by applying rates in physical units (e.g., France's carbon tax).

liter, kilogram, or cubic meter) or energy content (e.g., GJ or kWh); a tax rate that is not designed based on the carbon content of the fuels and can therefore vary across fuels, users, and sectors in ways that are not aligned with climate considerations. However, these tax rates can straightforwardly be expressed in those terms (e.g., USD/tCO_2). Therefore, despite being adopted to address other socioeconomic objectives (e.g., raising revenues, financing roads, addressing air pollution), indirect pricing helps to internalize a portion of the social costs of carbon and, therefore, these instruments provide a carbon price signal.

Metrics can also differ in their purpose and uses. This is illustrated in Figure 7, where a metric can have the purpose of describing, measuring progress, or guiding design and implementation. A metric is descriptive when it gives an account of the state of carbon pricing. If instead the metric expresses an evaluation relative to some standard, its purpose is to measure progress. Finally, a metric can be designed to provide guidance on how to first measure and then implement carbon pricing. The purpose of a metric is closely related to its use. For instance, descriptive metrics are typically used to understand trends or compare approaches, while metrics that measure progress and or provide guidance are generally used to evaluate.

Figure 7. A framework to understand carbon pricing metrics



Source: Authors.

4. A typology to understand CP metrics along three dimensions

4.1 Three dimensions to understand CP metrics

This section uses the framework described in section 3 and presents a typology for a comparative analysis of CP metrics based on three dimensions:

1. **Policy coverage:** Shown in the vertical axis of Figure 8, this dimension comprises two categories: price-based and non-price-based instruments. In turn, price based can be subcategorized into carbon pricing and non-carbon pricing, with carbon pricing including carbon taxes and ETS. Non-price-based instruments can include regulations, and direct government investments, among others.

2. **Rate/Form of carbon pricing covered by metric:** The horizontal axis in Figure 8 describes different carbon pricing forms. Form refers to whether the metric tracks positive (carbon taxes, ETS), negative (subsidies), implicit (fuel taxes), or explicit (carbon taxes) CP.

3. **Purpose of the metric:** A third dimension describes the purpose of a CP approach, including describing current pricing (positive), providing a normative assessment of the magnitude, and providing guidance.

Together these three dimensions form four quadrants in a typology presented below. This typology helps to understand how the approaches relate, differ, and complement. Finally, it is helpful to identify areas for future research.

4.2 Placing PCT Partners' metrics within the typology

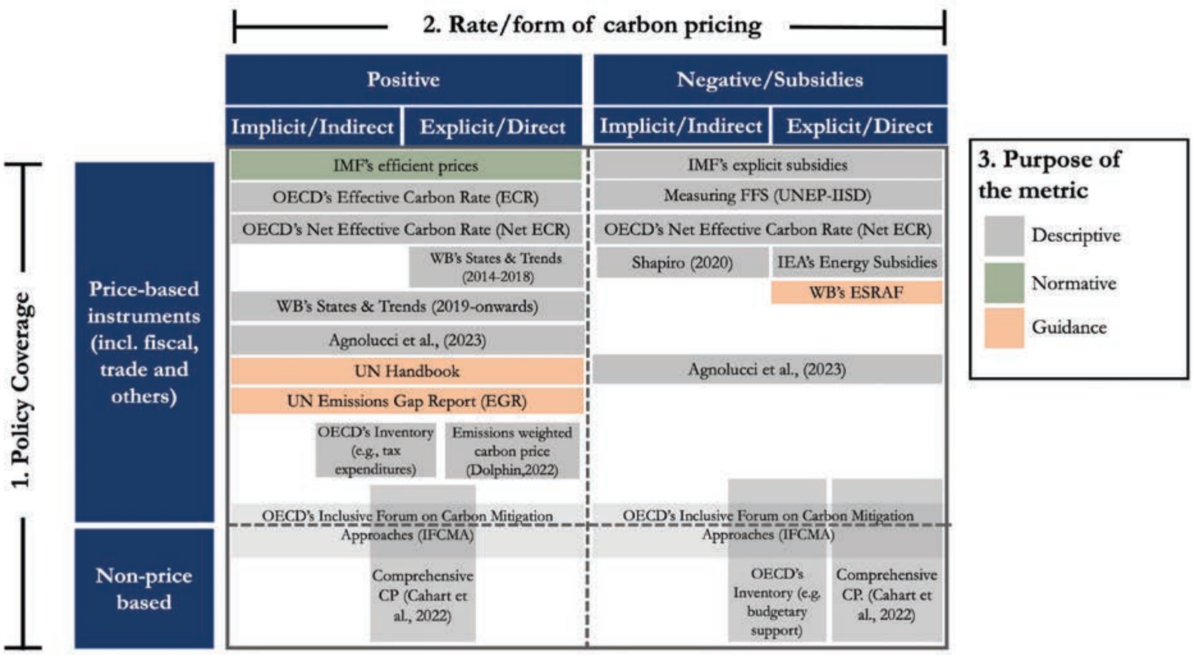
The intersections of these three dimensions help understand the differences and complementarities of PCT Partners' metrics. Each PCT partner's metric can be placed within the three dimensions, noting that the exercise of providing a typology naturally resorts to simplification. In several of the reports discussed in this paper, there are overlaps between the descriptive metrics and analyses that identify priorities for action. For instance, while the ECR is a descriptive metric, ECR reports also provide guidance for reform, and the ECR dataset itself allows for comparisons to identify priorities for reform. In sum, the typology is intended to illustrate and facilitate comparison, and it does not intend to redefine metrics.

The OECD's approach to estimating ECR is illustrated in the upper left quadrant of Figure 9. The ECR focuses on price-based policies that set a positive price on carbon and is, therefore, placed in the upper-left quadrant. The Net ECR deducts fossil fuel subsidies from the ECR, and therefore it is also placed in the upper-right quadrant. Finally, both the ECR and the Net ECR are descriptive and presented in gray in Figure 9. However, the ECR metric can also be used to assess current pricing and identify reform priorities. In that sense, it further provides guidance and has some normative elements.

By answering the question of "how far countries have attained the goal of pricing all energy-related carbon emissions at a benchmark," the Carbon Pricing Score represents a normative yardstick. Thus, the OECD's Carbon Pricing Score is illustrated in green, and placed in the upper-left quadrant where both price-based policies and positive carbon pricing intersect.

OECD's Inventory of Support Measures for Fossil Fuels deals with policies that are broad in nature, both regarding the coverage dimension and the rate/form dimension. Tax expenditures—one of the measures covered by the Inventory- refer to the amount of tax reduction relative to the benchmark tax, meaning that a positive tax rate still applies. On the other hand, budgetary support—the other type of measure covered by the Inventory- could be seen as a form of negative carbon pricing or subsidy. Therefore, the OECD Inventory is shown in both categories along this dimension: positive and negative/subsidies. For the policy coverage dimension, budgetary support measures cover both price and non-price-based policies. Therefore, the budgetary support part of the Inventory is placed in the lower-right quadrant, while the tax expenditure side is placed in the lower-left quadrant of Figure 9.

Figure 8. Typology and comparison of PCT Partners' carbon pricing metrics along three dimensions



Note: Positive and negative carbon pricing may overlap.
Source: Authors.

IMF metrics deal with subsidies and efficient fuel price estimation and are therefore presented in the positive and negative categories along the horizontal dimension. The explicit subsidy metric is descriptive and placed in the upper-right quadrant. However, efficient energy prices are normative and placed in the upper-left quadrant of Figure 8.

In the State and Trends of Carbon Pricing report, the World Bank has historically measured direct carbon pricing policies, namely carbon taxes and emissions trading. The metrics presented by the World Bank include country pricing and coverage, therefore are descriptive and presented in gray in Figure 8. Since World Bank metrics deal with pricing policies and positive carbon pricing, they are placed in the upper-left quadrant of Figure 8. However, from 2019, the State and Trends of Carbon Pricing report has started discussing (although not yet measuring) the role of indirect pricing; therefore, it is also presented in two blocks: one from 2013-2018 and one from 2019-onwards, representing direct and indirect pricing, respectively.

The UN Handbook's purpose is to guide developing countries on carbon taxation: it is placed in the upper-left quadrant and marked as a guidance approach in Figure 8. Similarly, the EGR 2021 report provides guidance on the role of carbon pricing in bridging the emissions gap: the EGR is placed in the upper left quadrant and marked as a guidance approach. Conversely, the UN-IISD joint publication on measuring fossil fuel subsidies is placed as descriptive and in the upper-right quadrant.

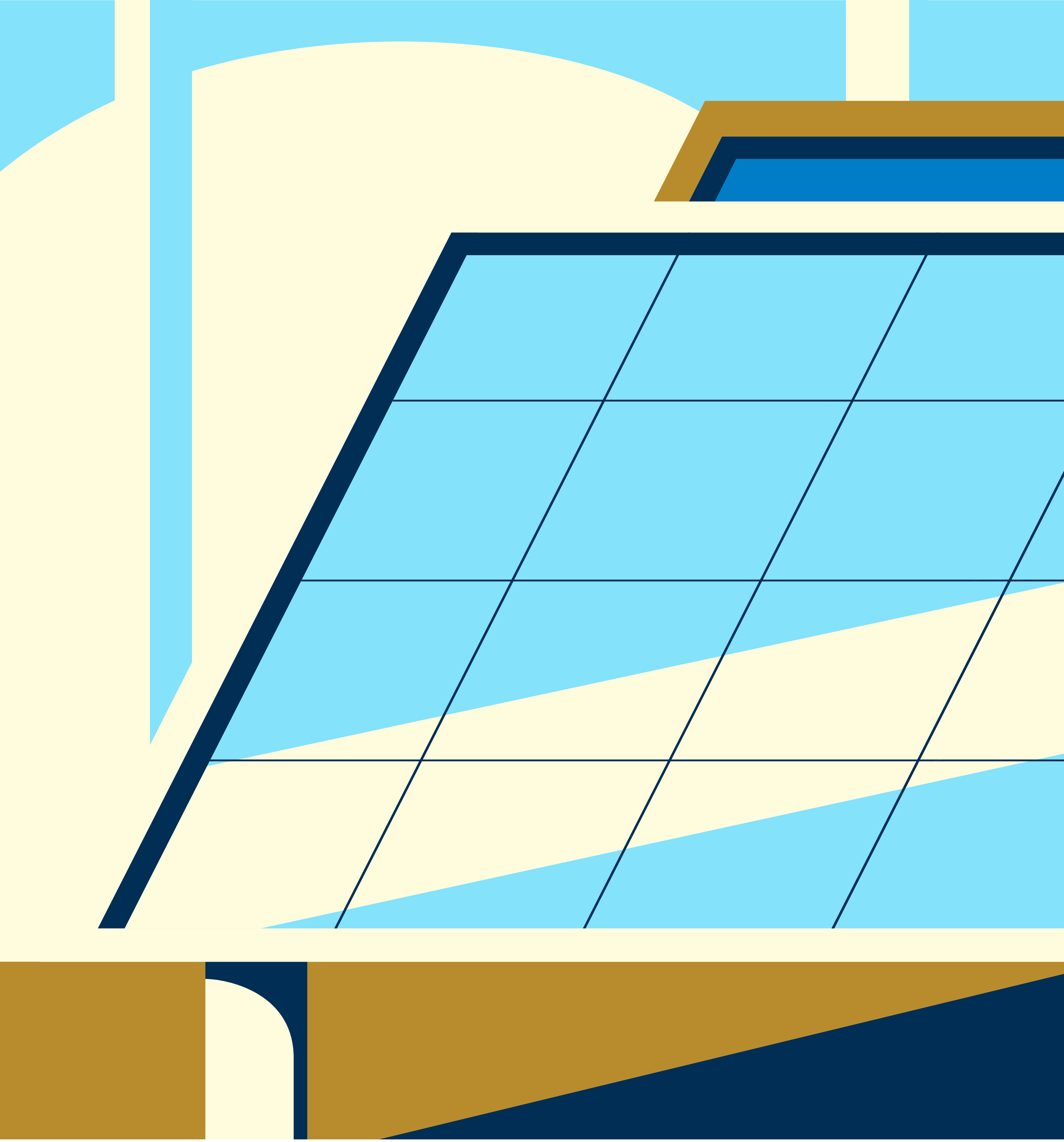
4.3 Key takeaways from the typology and metric comparison

Most CP metrics are descriptive. Only a few metrics stand out as normative. IMF's Getting Energy Prices Right is normative because it highlights the gap between efficient fossil fuel prices and observed retail prices. A couple of metrics guide the implementation of CP instruments or fuel subsidy removal, as is the case for the UN Handbook and the World Bank ESRAF.

Despite the diversity, there is convergence on the need to look at direct/explicit and indirect/implicit forms of carbon pricing. This can be observed in the upper-left area of Figure 8. While the OECD was a pioneer in this regard, all PCT Partners' approaches coincide with the need to track both forms.

The PCT Partners' metrics are strongly complementary; available methodologies that measure subsidies provide complementary assessments. These methods include the IEA's price-gap approach, OECD's inventory approach, and IMF's efficient tax approach.

The comparison allows for identifying areas for future research. Other fiscal policies not discussed in this paper are likely to effectively create positive or negative prices on carbon, such as tax incentives for e-mobility. The OECD finds that "removing or reducing the favorable tax treatment of company cars and the deductibility of commuting will strongly contribute to more efficient transport and location choices" (Van Dender, 2019). By allowing the deduction of car commuting costs from taxable household incomes, authorities induce households to opt for car commuting (Van Dender, 2019). Together with the topic of car commuting, the tax treatment of parking could also become an interesting area of future joint or individual PCT Partner's work (Van Dender, 2019; Proost and Van Dender, 2001). Another new area of research could deal with the role that trade policies play in setting implicit carbon prices. For example, low and high-carbon intensive goods, on average, face different trade tariffs (Shapiro, 2020), thus studying this tariff differential could be an interesting area of joint or individual partner work. Finally, the study of fiscal policies targeted at deforestation-driving commodities could become an interesting area of joint work. Deforestation-driving commodities are taxed or subsidized in ways that change the absolute and relative prices of these goods in ways that may not be aligned with their GHG emissions contribution.



5. Metric comparison based on technical considerations

A comparative analysis of the existing CP metrics can also build on the different technical elements, strategies, and assumptions within the methodologies adopted by the Partners. Without aiming to be exhaustive, this section highlights a few important technical elements to serve a better understanding of the reasons underlying different estimates at the country level, namely: 1) calculation of price levels, 2) approaches to estimating coverage when policies overlap, 3) benchmarks used, and 4) coverage of refunds, exemptions, and rate reductions.

5.1 Approaches to calculate direct/ explicit carbon prices

PCT Partners adopt different approaches to calculating price levels in their metrics. Understanding the differences in approaches can be helpful for policymakers in the interpretation of the metrics.

The State and Trends of Carbon Pricing report is published every May. The prices published by the World Bank show the price level of carbon taxes or ETSs as of April 1st. In the case of carbon taxes, the carbon tax rate in effect at that point in time is used. For ETS, prices are based on auction results or secondary prices. The World Bank follows this approach, first with the objective of promoting temporal consistency; and second, because reporting as of April 1 allows to capture any rate changes on carbon taxes that take effect from the beginning of the calendar year. Capturing rate changes based on calendar years is less important in the case of ETS.

The OECD uses average ETS permit prices in its calculation of Effective Carbon Rates. ETS permit prices are calculated by taking the average permit price observed at auction across a year of operation. The objective of this approach is to smooth out the effects of short-term fluctuations in permit prices. In the case of the OECD, an ETS average auction price is assigned to all CO_2 emissions from energy use subject to the ETS, regardless of whether permits were received via free allocation or whether the permit was purchased[11]. Whenever no auctions are in place, an alternative approach is used. For example, no auction has taken place in Korea while the ECR 2016 was being drafted, therefore the authors used the average permit price as traded at the Korea Exchange in the first half of 2015. For taxes, the OECD uses the rates as of April 1, as they are not as volatile as ETS permit prices.[12]

All approaches have advantages and shortcomings. Using averages smooths out short-term price variations, which allows for separating the signal from the noise. However, the general problem with using averages is that by design, they do not show variations in prices and might mask important price developments. The approach of presenting data as per the date of collection also has advantages and disadvantages. It allows for temporal consistency and can expose price variability otherwise masked by averages. However, on the downside, it might pick up too much of the variations, adding more noise to the signal. Understanding the different approaches might be useful for countries comparing their price rates across different metrics.

11 In addition to the ECR discussed in this paper, the OECD reports an Effective Average Carbon Rate (EACR), which corrects for free allocation. (OECD, 2021)

12 In the exceptional case where tax variance is high the OECD uses a yearly average of the tax rates.

5.2 Approaches to estimating coverage when policies overlap

Countries may implement more than one carbon pricing instrument within their jurisdiction. When jurisdictions/countries have two or more systems in place, overlaps between policies must be accounted for to avoid double counting of the price signals. There are different approaches to account for overlaps, some of which are described below.

To account for instrument overlap, the State and Trends of Carbon Pricing report uses the sum of emissions covered by each carbon tax or ETS minus the sum of emissions covered by both (the overlap) instruments. In most cases, the overlap estimate is provided directly by the jurisdictions. In others, it is estimated by the World Bank and verified by the jurisdiction.

ECR has three components: carbon taxes, other specific taxes, and ETS permit prices. The methodology to integrate the three components and account for instrument overlap involves three steps: 1) sectoral breakdown of the TEU database is adjusted to match the requirements for calculating ECRs; 2) combined ETS + tax coverage (when emissions are subject either to a tax or an ETS) is calculated; 3) impact of ETS on carbon taxes is adjusted case by case. Box 1 provides further details on how 2) is estimated.

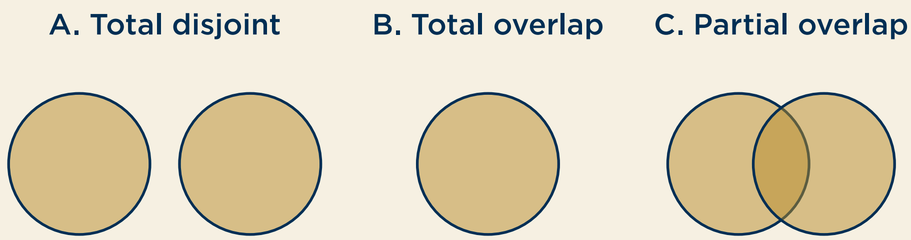
Box 1. OECD estimation of combined ETS + tax coverage

The calculation of combined emissions trading and tax (carbon and excise coverage) involves two steps. The first step involves using the TEU database information on tax rates and coverage for 30 individual users/industries and grouping it into the six sectors of the ECR. Coverage data on the ETS is based on emissions at the facility level, not fuels. That means that matching ETS coverage to the TEU database relies on the assumption that emissions from each fuel used by an industry are equally subject to an ETS. In other words, if 60% of the emissions of an industry are subject to the ETS, it is assumed that 60% of emissions from each fuel used by that industry is subject to the ETS.

Second, the combined ECR coverage (ETS and taxes) needs to be estimated. To calculate the combined coverage of effective carbon rates, i.e., the combined coverage of taxes and tradable emission permit prices, the OECD uses extensive information on emissions subject to taxes and ETSs.

Conceptually, there are three options as shown in figure B1: 1) either emissions subject to tax and ETS are entirely disjoint, 2) emissions subject to a tax and ETS entirely overlap, or 3) there is partial overlap.

Figure B1. Combined ECR coverage



The third step involves adjusting the Carbon Tax rate based on the rules that apply in a particular jurisdiction. In some countries, such as Finland and the United Kingdom, carbon taxes apply to emissions that are also covered by an ETS, increasing the carbon price applied. In other countries, such as France and Germany, the domestic carbon pricing instruments generally only apply to emissions that are not already covered by the EU ETS.

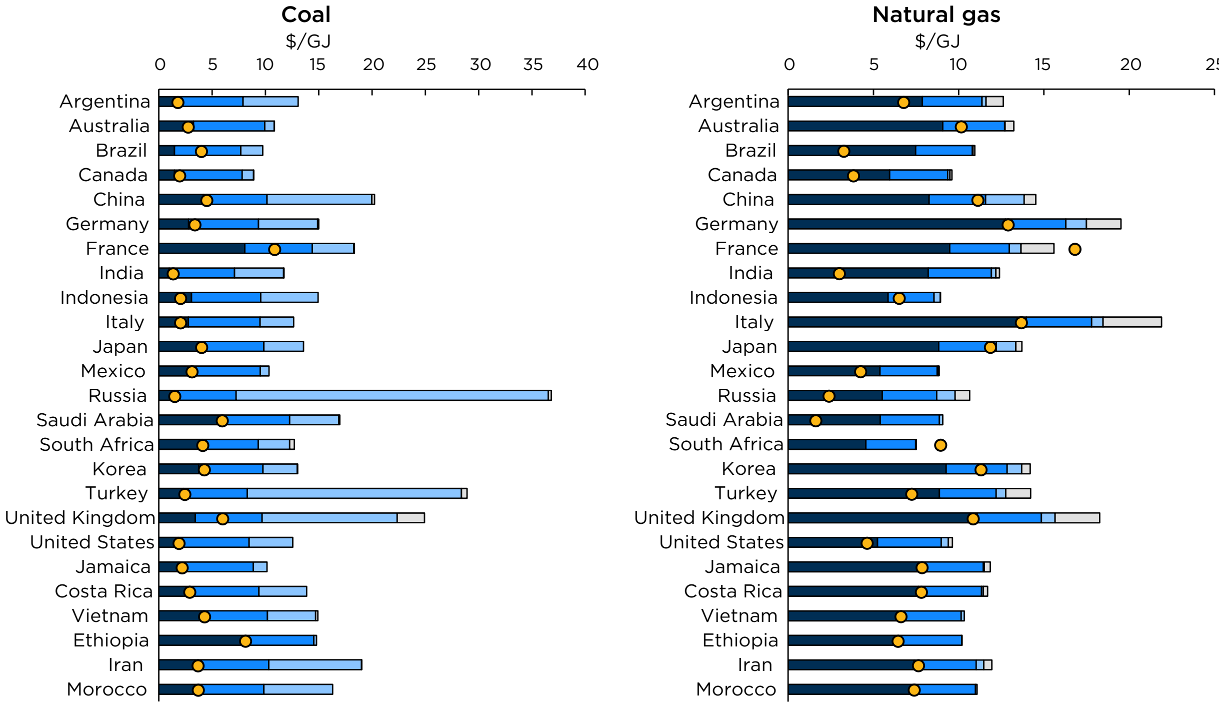
5.3 Benchmarks

Metrics that are descriptive provide useful information on the state and trends of carbon pricing levels. When disaggregated they also allow for comparisons, e.g., across sectors or fuels in a country. However, without a reference point, tracking progress is limited to a few comparisons. Benchmarks are used to compare current prices to desirable levels. Some principles can inform those desirable levels. For example, a benchmark can be chosen as the price that achieves full internalization of the social costs of carbon. It can also be chosen as the price that allows for the achievement of a certain target (e.g., net zero emissions). The approaches taken by the Partners differ and are summarized here.

OECD's ECR employs a 60EUR/tCO_2 and 120EUR/tCO_2 benchmark. The 60EUR/tCO_2 benchmark is a mid-range estimate of current carbon costs. This figure is also a low-end estimate of the climate damage caused by each ton of CO_2 emitted in 2030 and the carbon price that would be needed by 2030 for consistency with net-zero emissions targets. The 120EUR/ tCO_2 benchmark is a mid-range estimate of carbon prices required by 2030.

The IMF suggests comparing the current prices against their efficient level, that is, the level that incorporates supply plus all environmental costs (road damage, accidents, congestion, local pollution, and contribution to global warming), as shown in Figure 9. The IMF estimates an efficient price level for each fossil fuel by country. The IMF has also put forward the proposal for an International Carbon Price Floor (ICPF). The ICPF proposal is designed to scale up global mitigation action by overcoming obstacles to unilateral action. Noting that, even if the current 2030 pledges were achieved, emissions reductions would fall short of those needed to limit global warming below 2°C, therefore arguing for the need for an additional mechanism to reinforce the Paris Agreement. The IMF analyzes the effects of differentiated price floors dependent on development level. Price floors of USD 25, USD 50, and USD 75 per ton of CO_2 for low-income emerging market economies (EMEs), high-income EMEs, and advanced countries would reduce energy-related CO_2 emissions by 23-24 percent compared to business-as-usual (Parry et al., 2021b).

Figure 9. Efficient and current fuel prices in selected countries: IMF

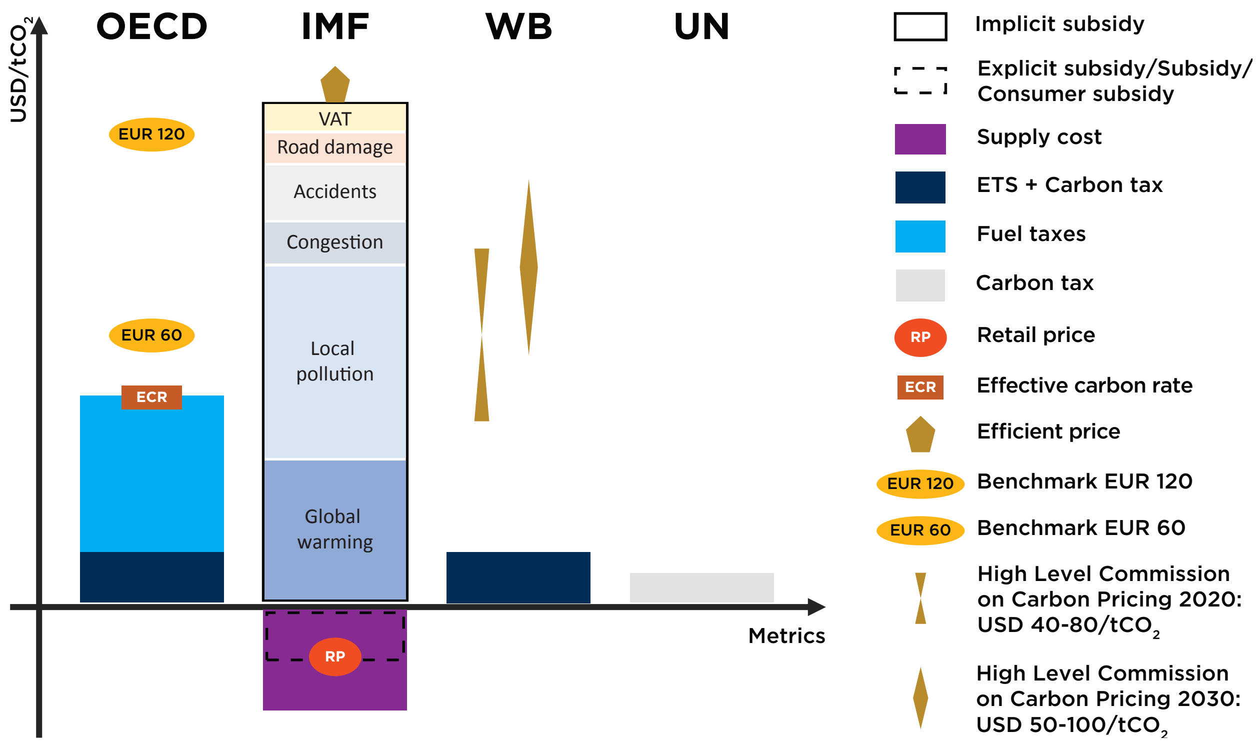


Source: Parry et al., 2021.

The World Bank compares the current levels of pricing against two benchmarks recommended by the High-Level Commission on Carbon Pricing. In 2015, during the COP held in Marrakech, the High-Level Commission on Carbon Pricing was formed and tasked to identify carbon price corridors to guide the design of carbon-pricing instruments. State and Trends of Carbon Pricing report uses the Commission's USD 40-80/tCO_2e corridor for 2020, and the USD 50-100/tCO_2e corridor for 2030 to compare against current levels of carbon pricing. For instance, the 2022 State and Trends of Carbon Pricing report finds that "less than 4% of global emissions in 2022 are covered by a direct carbon price at or above the estimated range required by 2030" (World Bank, 2022).

UN's Handbook cites benchmarks, including the OECD's EUR30/ tCO_2 and IMF's carbon price floors of USD 25/ tCO_2, USD 50/ tCO_2 and USD 75/tCO_2.

Figure 10. Benchmarks in carbon pricing approaches of PCT Partners



Source: Authors.

5.4 Approaches to dealing with rate reductions, refunds, exemptions and free allocation

Carbon prices with uniform rates for all emissions provide stronger incentives for investment in clean technologies (OECD, 2021). When a uniform carbon rate applies to all emissions in a jurisdiction, the marginal and average carbon prices are equivalent. Broad-based carbon prices placing the same rate on all emissions are an ideal to strive for.

Yet, in practice, design elements of carbon pricing instruments can drive a wedge between marginal and average carbon prices, affecting the dynamic (long-term) effectiveness of the instrument. For instance, some ETSs grant

EITE industries emissions allowances for free. Tax-free allowances are also used in some carbon tax designs. In both cases, free allowances reduce the average price that these industries pay for their emissions (as emitters only have to pay for a share of their emissions), yet the marginal price of emissions set by the carbon pricing instrument is kept unaltered. (OECD, 2021; Fluess and Van Dender, 2020; Dolphin and Xiahou, 2022). The OECD calculates an Effective Average Carbon Rate (EACR) to adjust for tax-free allowances and free permit allocation on total expected profits. The EACR is thus useful to compare incentives for investment in low-carbon technologies (OECD, 2021). The latest report (OECD, 2022) finds that free allowances are most common in the industrial sector, but less so in the power sector. Phasing out free allowances could generate substantial revenues and, at the same time, increase the effectiveness of the ETS.

Rate reductions, refunds and exemptions are part of tax expenditures and often target specific groups of consumers, fuels, or fuel uses (OECD, 2015). As a result, tax expenditures leave a fraction of energy usage unpriced, weakening carbon pricing. The OECD relies on detailed information on tax expenditures, including reductions in or exemptions from energy taxes. In the methodology outlined in the 2015 TEU report (OECD, 2015), tax exemptions, refunds and credits, reduced rates and other tax expenditures that reduce the effective tax rate are thus considered. The latter approach is also used in the ECR, as the ECR broadens the scope of the TEU by including ETS.

Design choices can also alter the carbon price signal of carbon taxes. The political economy of carbon taxes may require rate reductions, zero rates and exemptions for selected fuels, thus leading to differentiated tax rates by fuel type (or sector). The main difference between tax-free allowances and rate reductions and exemptions is that while the former widens the gap between marginal and average prices, the latter modifies the marginal price faced by certain fuels. In addition, rate reductions and exemptions often cause misalignment of carbon tax rates with the carbon content of the fuels. The State and Trends of Carbon Pricing report's (and the Carbon Pricing Dashboard) direct carbon pricing indicators include, when available, differentiated carbon tax rates in the form of a range of rates, i.e., including a minimum and a maximum rate. For instance, Mexico's carbon tax applies different rates per tCO_2 across fuels going from $0.42/$tCO_2$ to $4/$tCO_2$. The indirect component of the total carbon pricing metric proposed by Agnolucci et al. (forthcoming) reflects exemptions whenever these are reflected in the retail price of fuels.

6. Country examples: How to understand and use the typology

The typology presented in this paper highlights that no single metric can summarize all dimensions of carbon pricing. Understanding the key differences between the metrics is thus useful for policymakers in countries aiming at introducing, assessing, and/or improving their carbon pricing. This section presents examples of how the countries can use the metrics, how to understand some of the key differences, and what key common messages emerge from the metrics.

The methodology to produce the analysis of this section is detailed in Appendix 1. Given the different methodologies adopted by the PCT Partners, a few methodological clarifications of the comparisons in sections 6.1 and 6.2 are necessary:

1. **Sectoral aggregation differs across metrics:** The OECD and IMF use different sectoral aggregations.[13] For example, for transport, the IMF uses a single sector called transport while the OECD uses two sectors—*road* and *off-road.* For purposes of the comparison done here, data at the subsector level (e.g., road and off-road) was aggregated at the sector level. Therefore, differences between the metrics can be attributable to the aggregation done here, instead of more fundamental differences. See Appendix 1 for more details.

2. **The metrics are calculated at different levels of disaggregation.** This is illustrated in Figure 10. The OECD disaggregates the different positive carbon pricing components: carbon tax, ETS, and excise taxes. The IMF's focus is on the measurement of implicit and explicit subsidies. However, the database published by the IMF does provide "energy tax" data. The energy tax data aggregates excise taxes, carbon taxes, and emissions permit prices. The World Bank provides carbon taxes and ETS permit prices at the jurisdiction level, but currently, this is not disaggregated by sectors or fuels.

13 For instance, OECD's sector "Residential and Commercial" is compared against IMF sector "Residential".

3. **Fuel definitions differ across metrics.** For instance, coal for the OECD is aggregated as "coal and other solid fossil fuels," which is not the case for the IMF. This suggests that differences between the metrics as presented here might be partially attributable to how the comparison is done in this paper, rather than more fundamental differences.

6.1 PCT metrics across fuels and sectors in the OECD member countries: The most polluting fuels face the lowest carbon prices

Fossil fuels face different carbon prices, with the most polluting fuels facing the lowest rates. Figure 11A below highlights the differences in carbon pricing across fuels for OECD countries (i.e., OECD membership) in 2021. Coal—the most polluting fuel—faces one of the lowest carbon prices compared to the rest of the fuels. The metrics used by PCT Partners coincide with this finding.[14] Conversely, transportation fuels (gasoline and diesel) face the highest carbon prices. While the magnitude of the variation in carbon pricing differs depending on the metric, the general message is the same: energy/excise taxes make up for the largest share of carbon pricing in transportation fuels, with carbon taxes playing a more modest role.

Carbon prices differ significantly across sectors in OECD countries, with transport and the residential sectors facing the highest prices. Overall, a ton of CO_2 is priced highest in the transport sector with nearly all pricing coming from fuel taxes[15] (see Figure 11B); PCT Partners' metrics concur with this finding. For the OECD countries, a substantial part of the carbon pricing in the power (electricity) and industrial sectors is applied via emissions trading. However, the net carbon rate for both sectors remained below USD 50/tCO_2 in 2021. ETS prices play a larger role in the power sector, while fuel taxes remain an important carbon price component in the industrial sector. This might be a result of the exclusion of electricity excise taxes from the metrics presented.

14 Note that the World Bank's State and Trends of Carbon Pricing report data is available only at the national level; therefore, no disaggregated data by sector or fuel are shown here for the World Bank. Similarly, the UN does not publish carbon pricing data.

15 Note that this does not hold for all countries, e.g., Sweden.

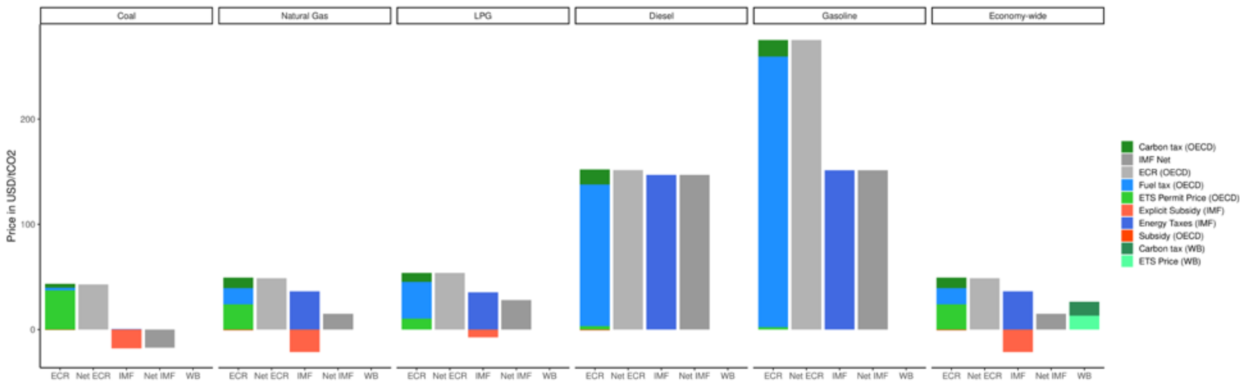
Most PCT Partners concur in their treatment of electricity taxes: they are not considered carbon prices, as excise taxes levied on electricity generally fail to distinguish between the carbon intensity of fuels used to generate electricity. However, Partners also note that, in combination with other instruments, electricity taxes may mimic the incentives of a first-best policy, i.e., feed-in-tariffs combined with electricity taxes.

Carbon taxes are an important, yet small share of the pricing in the transport and residential sectors. However, the level of carbon pricing from carbon taxes in the residential and transport sectors is almost double the level observed in the industrial or power sectors.

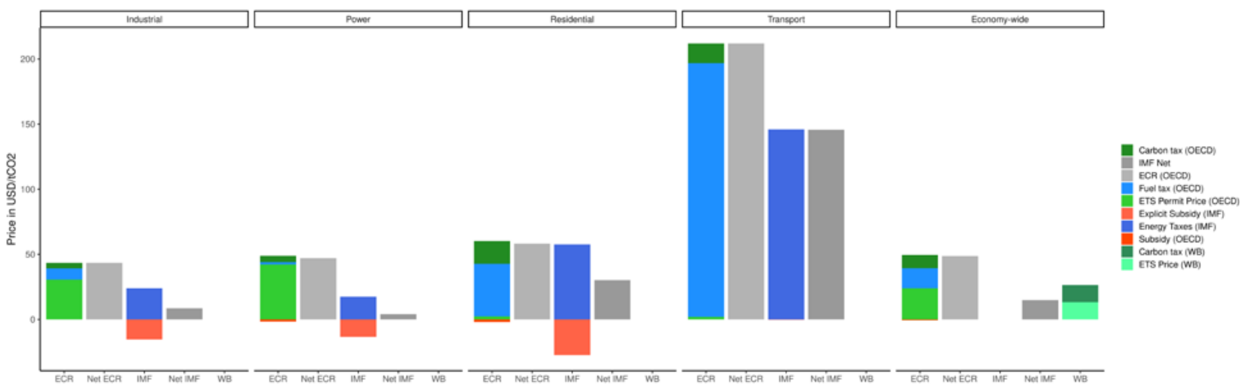
Analyzing the price of certain fuels across different sectors illustrates how carbon prices are aligned across the economy. Figure 11C illustrates the carbon prices that natural gas faces in different sectors. The net price is higher for the residential sectors while subsidies are also large. Carbon taxes and fuel taxes play a predominant role in the residential and transport sectors. Conversely, ETS prices play a predominant role in the industrial and power sectors and more so in the power sector. However, the net price per ton of CO_2 remains low for the industrial and power sectors as compared to the rest.

Figure 11. PCT Partners' metrics across different fuels and sectors

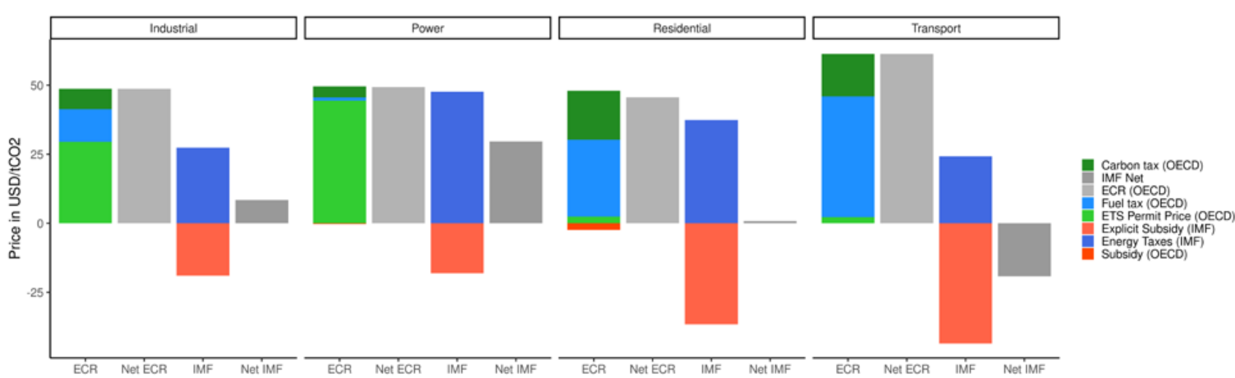
A. OECD membership: Carbon pricing across fuels (2021)



B. OECD membership: Carbon prices across sectors (2021)



C. OECD membership: Carbon pricing of natural gas across sectors (2021)



6.2 PCT partners' metrics across fuels and sectors in selected countries: Developing countries have experience in pricing carbon indirectly (implicitly), using fuel excises

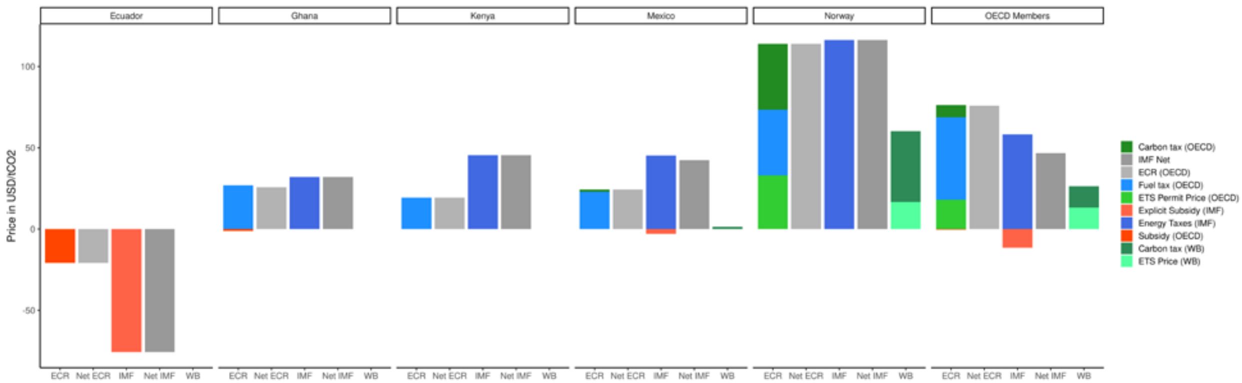
Developing countries have several decades of experience in taxing carbon indirectly (implicitly) through fuel excises and fuel subsidies. Five country examples (Ecuador, Ghana, Kenya, Mexico, and Norway) and the average of OECD member countries are presented below to illustrate the differences in pricing of carbon across different fuels and sectors both within and outside OECD's membership. Figure 12A shows carbon pricing at the national level (and the average of OECD countries). Currently, the World Bank only reports carbon pricing from direct instruments, i.e., carbon taxes and emissions trading. While Mexico, Norway, and the OECD members' average have direct carbon pricing instruments in place, this is not the case for Ecuador, Ghana, and Kenya. The differences in the metrics (e.g., ETS price permit averages) shown in Figure 11A reflect calculations done here for illustrative purposes (assumptions on sector aggregations and sector comparability, see Appendix 1), rather than substantial differences between the Partners' metrics.

Despite the lack of direct carbon pricing instruments (carbon taxes or ETS) in Ghana and Kenya, their levels of indirect carbon prices are comparable to the average carbon price of OECD countries. Figure 11B illustrates this for carbon pricing in the industrial sector. Developing countries can capitalize on decades of experience with indirect carbon pricing, i.e., fuel taxation and fuel subsidies, to introduce direct carbon prices via carbon taxes or emissions trading. Developing countries can also improve their current carbon pricing by broadening the base of fuel taxes, aligning rates to the carbon content of the fuels, and removing or reducing fuel subsidies.

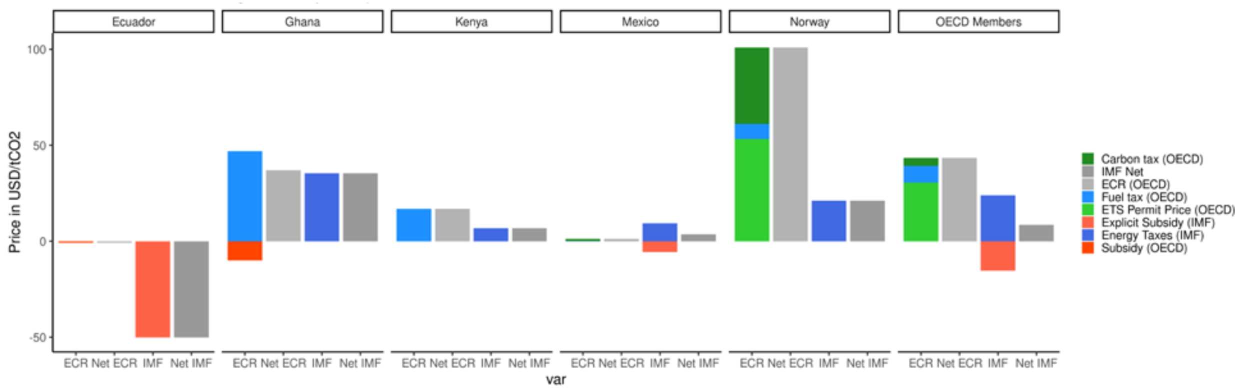
The levels of carbon prices applied to coal and diesel in the industrial sector show stark contrasts: CO_2 prices are significantly higher for diesel than for coal. In this small sample of countries, coal faces carbon price rates lower than USD 50USD/tCO_2, while carbon prices applied to diesel go well above the USD 100/tCO_2 mark. This finding is in line with the observation in section 6.1 for OECD countries. Despite small differences, this section confirms the findings previously highlighted in this paper: The most carbon-intensive fuels face some of the lowest carbon prices.

Figure 12. PCT Partners' metrics across countries, fuels, and sectors

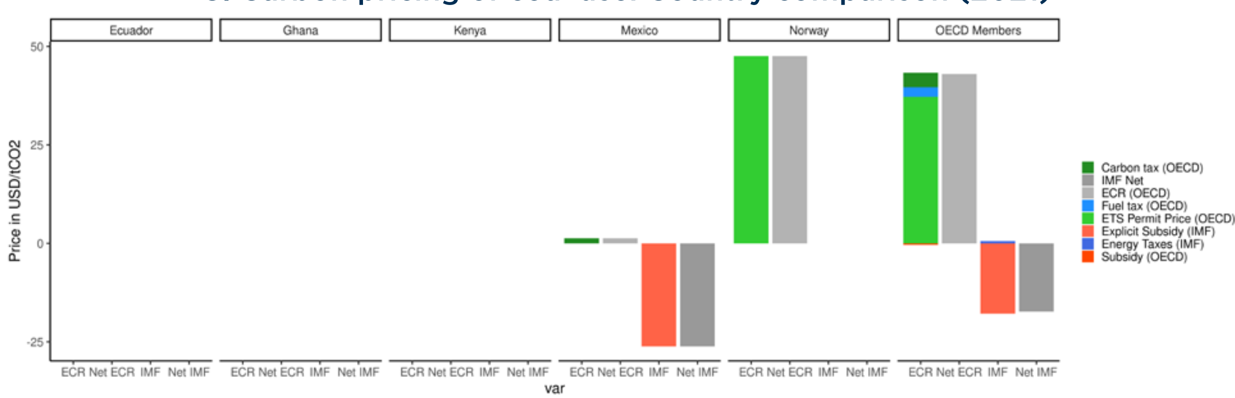
A. Carbon pricing across countries: Selected developing countries and OECD average



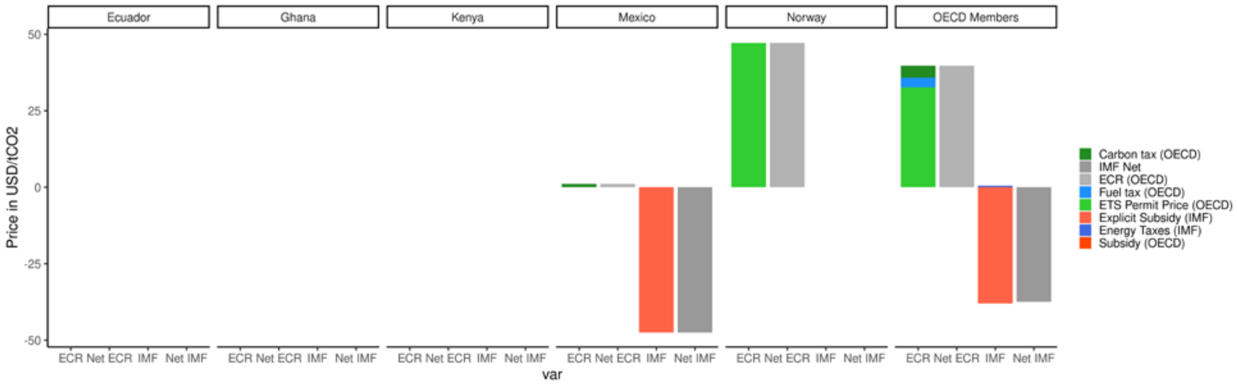
B. Carbon pricing in the industrial sector: Country comparison (2021)



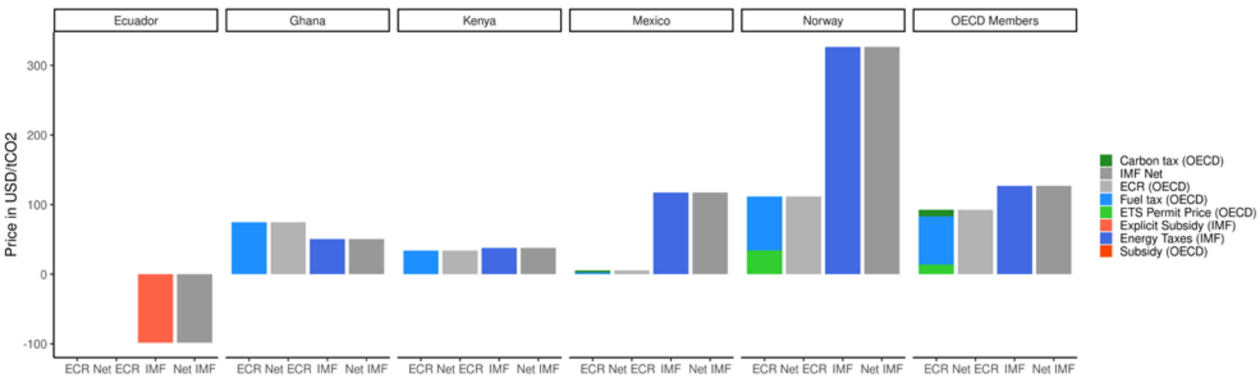
C. Carbon pricing of coal use: Country comparison (2021)



D. Carbon pricing of coal in industrial: Country comparison (2021)



E. Carbon pricing of diesel in industrial: Country comparison (2021)



Notes: Empty columns may be due to 1) that fuel is not used in that sector and country, or 2) that fuel-sector combination does not face a tax/subsidy within the country. In panel A, empty columns for the World Bank mean that there is no direct carbon pricing instrument in place in those countries. In panels C, D and E, countries with empty columns mean that there is no tax or subsidy for that fuel or fuel-sector combination.

7. Conclusions

Since the first carbon tax was implemented in 1990, the number of carbon pricing instruments has steadily increased. In 2022, 68 carbon pricing instruments are in operation (World Bank, 2022). Fuel (excise) taxes are older, more widespread, and, in some regions, of larger magnitude than explicit carbon pricing instruments. Fuel taxes dominated effective carbon rates in the OECD countries in 2018, representing 67% of the ECR marginal rates (OECD, 2022).

This increase in the use of carbon pricing instruments matches the development of a wide range of carbon pricing metrics. The metrics inform carbon pricing's current state, trends, and progress. Thus, they are critical tools for policymakers, businesses, and other stakeholders to make informed decisions on carbon pricing. Yet, metrics differ in the policies they cover (e.g., emissions trading), the forms of carbon pricing they focus on (e.g., explicit), and their purpose (e.g., descriptive). Metrics can diverge due to technical approaches (e.g., treatment of overlapping policies, how they aggregate sectors), geographic coverage, and the benchmarks they are compared to. The divergence in approaches presents policymakers and other stakeholders with scattered guidance.

This paper provides a first comparison of the carbon price metrics of the Partners of the Platform for Collaboration on Tax. Understanding the key differences between the metrics will be useful for policymakers in countries aiming to assess and improve their current carbon pricing levels.

Highlighting the key differences and complementarities, this paper proposes a framework and a typology to understand and compare carbon pricing metrics. No single metric can encapsulate all dimensions of carbon pricing and/or environmental taxation. The study shows that the existing metrics and approaches are complementary, and in that sense, they complete the carbon pricing landscape. In addition, this paper identified some common high-level messages emerging from the different approaches used by the PCT partners.

The importance of excise taxes (and subsidies) as contributing to equivalent carbon pricing is reflected in all carbon pricing metrics and/or approaches of PCT Partners. In the diversity, there is also convergence on the metrics of PCT Partners looking at positive CP in both its explicit/direct and implicit/indirect forms. For instance, OECD's ECR aggregates the price signals emerging from explicit carbon pricing instruments such as carbon taxes, ETS, and fossil fuel taxes. Similarly, the World Bank has started exploring the importance of indirect carbon pricing signals emerging from fuel taxes on consumption (World Bank, 2022).

Carbon pricing signals to date are insufficient. All PCT Partners highlight this message. Energy prices are poorly aligned with climate, environmental, and health costs. Strategies to improve alignment include the removal of fossil fuel subsidies, higher direct carbon prices (via carbon taxes or ETS), broadening the tax base of fuel taxes and aligning the rates with the social cost of carbon. According to the OECD, in 2018-2021, 59.3% of GHG were not subject to a positive carbon price, implying considerable opportunities to advance CO_2 pricing (OECD, 2022). The World Bank highlights that while direct carbon prices recently hit record highs in many countries, less than 4% of global emissions are currently covered by a direct carbon price within the range needed by 2030 (World Bank, 2022). The IMF stresses the need to get energy prices right by charging efficient fuel pricing levels (Parry et al., 2021). Finally, the UN highlights the need to align fuel taxes with their carbon content (UN, 2021c) to eliminate fuel subsidies that undermine carbon taxes (UNEP-IISD, 2019; UN, 2021; UN 2021b; UN, 2021c), and highlights the key role of environmental taxes in aligning fiscal policies with the commitments of the 2030 Agenda and the Paris Agreement (UN, 2021).

Current price signals are inconsistent with carbon content, as the most polluting fuels face the lowest carbon price rates. This finding emerges from most of the PCT Partners' approaches, noting that not all PCT Partners currently disaggregate the pricing data at the fuel and sector level.

The diversity of existing carbon pricing metrics responds to carbon pricing instruments taking several forms. A comprehensive approach to pricing energy rights will require removing (explicit, pre-tax) fossil fuel subsidies, increasing direct carbon prices to reflect the social costs of GHG emissions, and setting fuel tax rates based on the carbon content of the fuels. International cooperation on these aspects is important to support countries in their efforts to achieve net zero targets.

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Appendix 1. Country example applications: Data sources and methodological notes

The figures presented in section 6 require collecting data from various sources, matching sectors, and currencies. Three sources of data by the IMF, OECD, and the World Bank are used. The figures include metric estimates for 2021 because this is the year where most data are available for the different fuel and sector combinations. The data from the three sources has been processed as described below.

IMF data on fuel prices is taken from the joint IMF-World Bank *Climate Policy Assessment Tool (CPAT*) dataset. Other information required for calculation like consumption data and CO_2 emission factors is taken from the IEA Energy Balances and International Institute for Applied Systems Analysis (IIASA) GAINS model, respectively. The data is disaggregated for different fuel-sector combinations. Total energy taxes are calculated as the difference between the retail price and supply cost (if positive) of the fuel for that sector. VAT payments have been excluded from total energy taxes as the IMF follows a similar methodology. If the difference between retail price and supply cost is negative, then it is calculated as an explicit subsidy. The values are then aggregated to arrive at data for different fuels and sectors. All values are then converted to constant USD 2021 prices.

OECD's data is taken from the dataset linked to the *Pricing Greenhouse Gas Emissions* report (OECD, 2022). The data includes values in Euros per tCO_2 of taxes, subsidies, marginal permit price, and effective carbon rates for multiple fuels and sectors. The price is converted from EUR to USD using the exchange rate for the applicable year from the IMF dataset and then converting to constant 2021 USD prices.

Data from the World Bank's 2021 *State and Trends of Carbon Pricing* report has been used to calculate the World Bank Carbon Tax and ETS Price components for Figure 12-A. The unit prices for different Carbon Taxes and ETS instruments from the dataset were multiplied by their corresponding emissions coverage* and then summed to arrive at national aggregates. These aggregates (in constant USD 2021) are then divided by total national emissions to arrive at the ETS and Carbon Tax component of carbon prices. The average for OECD countries is calculated by taking a simple average for all OECD members (as of 2021) for which data was available.

The data from the two steps above is merged to create a combined dataset, which is then used for illustration purposes. The OECD and IMF use different sectoral aggregations; For example, for transport, the IMF has a single sector called *transport,* while the OECD has two sectors—*road* and *off-road.* Similarly, the IMF has one sector called *residential* and another called *services,* while the OECD uses *residential and commercial* as a single sector. Even when the sectors are the same, for example *industrial,* the internal composition of the sectors might differ, hence making a one-to-one comparison difficult. For the plots, sectoral data is processed assuming that the chosen sectors completely map with each other. For fuel-wise plots, it is assumed that the aggregate of all sectors over a single fuel will be the same for both the OECD and IMF. The values for the OECD Average are directly available in the TEU dataset. In the case of IMF data, these values are calculated by taking the average (i.e., simple average and not weighted by emissions) of all countries that were a part of the OECD in 2021.

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