



**OECD Series on Carbon Pricing and Energy
Taxation**

Effective Carbon Rates 2023

**PRICING GREENHOUSE GAS EMISSIONS THROUGH
TAXES AND EMISSIONS TRADING**



OECD Series on Carbon Pricing and Energy Taxation

Effective Carbon Rates 2023

PRICING GREENHOUSE GAS EMISSIONS THROUGH
TAXES AND EMISSIONS TRADING

This document, as well as any data and map included herein, are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Note by the Republic of Türkiye

The information in this document with reference to “Cyprus” relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the “Cyprus issue”.

Note by all the European Union Member States of the OECD and the European Union

The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

Please cite this publication as:

OECD (2023), *Effective Carbon Rates 2023: Pricing Greenhouse Gas Emissions through Taxes and Emissions Trading*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, <https://doi.org/10.1787/b84d5b36-en>.

ISBN 978-92-64-42935-2 (print)
ISBN 978-92-64-90153-7 (pdf)
ISBN 978-92-64-78864-0 (HTML)
ISBN 978-92-64-70204-2 (epub)

OECD Series on Carbon Pricing and Energy Taxation
ISSN 2958-0161 (print)
ISSN 2957-9899 (online)

Photo credits: Cover © west cowboy/Shutterstock.com; © Nivellen77/Shutterstock.com.

Corrigenda to OECD publications may be found on line at: www.oecd.org/about/publishing/corrigenda.htm.

© OECD 2023

The use of this work, whether digital or print, is governed by the Terms and Conditions to be found at <https://www.oecd.org/termsandconditions>.

Foreword

This report was prepared by the Tax Policy and Statistics division of the OECD's Centre for Tax Policy and Administration. It is unique in its comprehensive take on effective carbon pricing, integrating price signals that result from fuel excise taxes, carbon taxes and emissions trading systems into effective carbon rates.

This is the second report in the OECD series on Carbon Pricing and Energy Taxation. The report covers 72 countries increasing coverage relative to the first report in the series, *Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action*, encompassing all emissions trading systems in place in 2021. It provides an in-depth analysis of emissions trading systems in 2021 as well as of two common features of this carbon pricing instrument: free allocation and price stability mechanisms. Additionally, given the effect of the energy crisis and high inflation rates on the recent policy landscape, the evolution of emissions trading systems, fuel excise taxes and carbon taxes in 2022 and 2023 is analysed as well.

Detailed data on Effective Carbon Rates (ECR) are available for 45 OECD and G20 countries on the OECD website, for 2012, 2015, 2018 and 2021.

The project was led by Anasuya Raj under the guidance of Assia Elgouacem and the overall responsibility of Kurt Van Dender. The report was drafted by Anasuya Raj, with inputs from Konstantinos Theodoropoulos. Database design is by Konstantinos Theodoropoulos and the *Effective Carbon Rates* model was updated and implemented by Anasuya Raj. Information on 2021 carbon prices that result from taxes was obtained from the OECD's *Taxing Energy Use* database, which was recently updated by Jonas Teusch, Konstantinos Theodoropoulos and Astrid Tricaud. Information on emissions trading systems already implemented in 2021 was collected and processed by Anasuya Raj and Konstantinos Theodoropoulos. Information for emissions trading systems which have newly been implemented, have just been approved or for which a mandate has been established, was collected and processed by Anasuya Raj and Astrid Tricaud. Information on effective carbon tax rates in the road transport sector for 2022 and 2023 was collected by Bethany Millar-Powell, Konstantinos Theodoropoulos and Astrid Tricaud and processed by Anasuya Raj.

The authors would like to thank OECD colleagues David Bradbury, Luisa Dressler, Assia Elgouacem, Jane Ellis, Mathilde Mesnard, Dirk Röttgers, Jonas Teusch and Kurt Van Dender for their feedback and advice at different stages of the production of the report. They would also like to thank Arnau Risquez Martin and Nicolas Coent for providing timely energy-use data without which the update of the ECR database to 2021 would not have been possible. Karena Garnier, Hazel Healy, Rebekka Hviid Kanstrup, Michael Sharratt, Violet Sochay, Carrie Tyler and Antonia Vanzini improved the presentation and dissemination of the work.

The OECD Secretariat would like to thank the delegates of the Joint Meetings of Tax and Environment Experts, and their colleagues in national government administrations for their assistance with the provision of data, for their feedback on the data and the report, and for their support for the area of work.

Table of contents

Foreword	3
Executive summary	7
1 Introduction	11
1.1. Limiting global warming	11
1.2. The OECD Effective Carbon Rates	13
1.3. Scope of the present edition	17
References	20
Notes	23
2 Effective Carbon Rates in 2021	24
2.1. Effectives Carbon Rates in 2021	24
2.2. Other greenhouse gas emissions	29
References	33
Annex 2.A. Breakdown of Effective Carbon Rates by instrument and country	34
Notes	37
3 Emissions trading systems	38
3.1. Carbon taxation versus emissions trading systems	38
3.2. Emission trading systems in 2021	41
3.3. Developments in Emissions Trading Systems since 2021	49
3.4. Free allocation	54
3.5. Price stability mechanisms	62
References	66
Annex 3.A. Evidence for carbon pricing-induced carbon leakage and competitiveness losses	74
Notes	76
4 Effective carbon tax rates from 2021 to 2023: Latest trends from the road transport sector in OECD and G20 countries	78
References	86
Notes	87
Annex A. Results including CO ₂ emissions from biofuel combustion	88
References	93

FIGURES

Figure 1.1. Implementation and ambition gaps	11
Figure 1.2. Effective carbon rates and sub-indicators	14
Figure 2.1. Distribution of Effective Carbon Rates	24
Figure 2.2. Proportion of CO ₂ e emissions priced at different ECR levels by sector	25
Figure 2.3. Carbon pricing instruments and share of GHG emissions by sector	27
Figure 2.4. ECR levels by fuel and sectoral composition of fuel emissions	28
Figure 2.5. Share of CO ₂ emissions from energy use in total GHG emissions	29
Figure 2.6. Share of other GHGs emissions in total emissions and importance of agricultural emissions in a country	30
Figure 2.7. Sectoral composition of other GHG emissions	31
Figure 2.8. GHGs responsible for other GHG emissions	32
Figure 3.1. Shares of CO ₂ emissions from energy use priced by ETSS	42
Figure 3.2. Share of sectoral total emissions covered by an ETS	43
Figure 3.3. Emissions trading systems phases	44
Figure 3.4. Austria ECR	51
Figure 3.5. Mexico ECR	51
Figure 3.6. Simulated Indonesia ECR profile	52
Figure 3.7. Simulated Ukraine ECR profile	53
Figure 3.8. Share of free allocation of allowances in total verified emissions by country	55
Figure 3.9. Free allocation by industrial subsector and aviation in the EU ETS	56
Figure 3.10. Permit price volatility in selected ETSS	62
Figure 4.1. Share of fuels in CO ₂ emissions in the road transport sector	81
Figure 4.2. Evolution of effective carbon tax rates in the road transport sector since 2021	83
Figure 4.3. Share of CO ₂ emissions from energy use in the road transport sector which underwent a decrease or an increase in taxes	84
Figure 4.4. Share of CO ₂ emissions in the road transport sector subject to different tax rate levels	85

TABLES

Table 1.1. ECR sectors and users	14
Table 1.2. Fuel category breakdown	15
Table 3.1. Evolution of coverage and rates of explicit carbon pricing instruments between 2018 and 2021	38
Table 3.2. ETS characteristics across different jurisdictions in 2021	45
Table 3.3. Average permit price changes between 2021 and 2023	49
Table 3.4. Total share of free allocation in countries' sectors subject to ETSS	58
Table 3.5. EMCRs and EACRs in countries or supranational jurisdictions with an ETS	59
Table 3.6. Price stability mechanisms	63
Table 4.1. Tax rate changes in current LCU in the road transport sector between 2021 and 2023	80
Table 4.2. From tax rates per common commercial units to tax rates per tonne of CO ₂	81

Follow OECD Publications on:



<https://twitter.com/OECD>



<https://www.facebook.com/theOECD>



<https://www.linkedin.com/company/organisation-eco-cooperation-developement-organisation-cooperation-developpement-eco/>



<https://www.youtube.com/user/OECDiLibrary>



<https://www.oecd.org/newletters/>

This book has...

StatLinks 

A service that delivers Excel® files from the printed page!

Look for the **StatLink**  at the bottom of the tables or graphs in this book. To download the matching Excel® spreadsheet, just type the link into your Internet browser or click on the link from the digital version.

Executive summary

The adverse impacts of climate change on human societies and nature are increasingly well-known and highlight the need to accelerate the transition to net-zero greenhouse gas (GHG) emissions, by targeting carbon dioxide (CO₂) and other GHGs such as methane, nitrous oxide and fluorinated gases. Cutting and eventually phasing out GHG emissions would limit the adverse impacts from climate change on economies while improving other environmental outcomes such as air and water quality. Delaying the transition towards net zero GHG emissions will maintain dependency on carbon-intensive capital and engender higher future costs. Successfully transitioning to net-zero GHG emissions requires effective mitigation policy packages, which include carbon pricing, a cost-effective policy instrument that also raises revenue that can be deployed to support the transition.

This fourth edition of *Effective Carbon Rates 2023* sheds light on the state of carbon pricing, encompassing fuel excise taxes, carbon taxes and emissions trading systems as of 2021, with updates reflecting developments up to 2023. The policy instruments covered directly increase the cost of emitting GHGs, thereby stimulating a transition in production, consumption and investment choices to low- or zero-carbon alternatives.

The analysis covers 72 countries, collectively emitting approximately 80% of global GHG emissions in 2021. The use of a common methodology to track carbon pricing efforts ensures comparability across countries and sectors. Providing comprehensive and comparable information on the current state of GHG emissions pricing can assist policymakers in establishing priorities and improving carbon mitigation policies. For example, improving such policies can be done by increasing prices, broadening the coverage of the pricing instruments and introducing complementary mitigation policies.

Within each of the 72 countries, the effective carbon rates (ECRs) are measured across seven sectors. These sectors include six economic sectors which together account for all CO₂ emissions from energy use – agriculture and fisheries, buildings, electricity, industry, off-road transport and road transport. The seventh sector captures other GHG emissions from methane (CH₄), nitrous oxide (N₂O), fluorinated gases (F-gases) and process CO₂. The report highlights the structure of ECRs across countries and sectors in 2021; detailed information on ECRs is available on OECD Data Explorer.¹

The year 2021 witnessed significant developments on carbon pricing. China and Germany introduced new ETSs, while Canada strengthened its federal benchmark criteria for explicit carbon pricing (i.e. carbon taxes or emissions trading systems). Moreover, many ETSs saw a significant increase in permit prices since 2021, particularly the European Union emissions trading system (EU ETS). The policy landscape has undergone transformations since 2021 due to the energy crisis compounded by Russia's war of aggression against Ukraine, triggering responses from both governments and market participants to attenuate the impact of energy price hikes. These developments have had implications for carbon pricing in 2022 and 2023.

Key findings

In 2021, 58% of the approximately 40 billion tonnes of GHG emissions were unpriced in the 72 countries covered in this report, with significant variation of coverage, prices and pricing instruments across sectors and countries.

- About 16% of GHG emissions were priced at EUR 30 per tonne of CO₂ or more, and 7% above EUR 60 per tonne of CO₂.
- The share of GHG emissions covered by carbon pricing varies across sectors, ranging from only about 4% of other GHG emissions being priced to around 93% of emissions priced in the road transport sector.
- Carbon price signals mainly arise from fuel excise taxes, which cover more emissions and have higher rates than the two explicit carbon pricing instruments (carbon taxes and emissions trading systems). However, there is heterogeneity across countries and sectors. In the road and off-road transport sectors and agriculture and fisheries sector, fuel excise taxes account for over 80% of the ECR. Carbon taxes tend to be more significant as a share in the ECR for the buildings sector than in other sectors. Electricity and industry sector emissions are predominantly priced through ETSs. Countries with the highest ECRs are more likely to have at least partial coverage of their emissions by an ETS and have the highest carbon taxes.

Emissions trading remains the main explicit carbon pricing instrument in 2021.

- In 2021, explicit carbon pricing mechanisms covered more GHG emissions worldwide than in 2018. In addition, there was a greater increase in coverage and marginal prices through emissions trading than via carbon taxes: coverage by emissions trading systems more than doubled between 2018 and 2021 (going from about 13% to 27% of CO₂ emissions from energy use in the 72 countries included in this report) and average permit prices across all ETSs and emissions covered increased by almost 40% (from about EUR 11.2 per tonne of CO₂ to EUR 15.5 per tonne of CO₂). In contrast, coverage (about 7% of emissions) and average tax rates (about EUR 12 per tonne of CO₂) remained almost the same for carbon taxes.
- Between 2018 and 2021, several ETSs were introduced and others entered new phases. In 2021, China and Germany implemented nation-wide sectoral ETSs, while several Canadian provinces adopted ETSs in response to the introduction of the federal carbon pollution pricing backstop system. In 2020, Mexico launched the pilot phase for a national ETS, with the operational phase to commence in 2023. The new phases or compliance periods of existing ETSs have had notable implications for cap levels, annual reduction or compliance factors, sectoral coverage and the calculations and rules governing the free allocation of allowances, overall increasing the stringency of the systems.
- In 2021, ETS coverage of CO₂ emissions from energy use ranged from about 99% in New Zealand to about 1.7% in Japan.
- ETSs commonly cover emissions generated by the electricity and industry sectors; however, an increasing number of new ETSs apply upstream (i.e. to fuel suppliers) and cover emissions from the buildings and transport sectors.

Contrary to most carbon and fuel taxes, marginal and average price signals often diverge in ETSs. This disparity arises from the free allocation of allowances, which can have implications for investment incentives and the revenue raised.

- The share of free allocation of allowances in verified emissions ranges from 19% to 100% across the countries covered in this report, with an average of 55%. The variation in shares can be attributed to countries' diverse industrial compositions, the maturity of their ETSs, political constraints, national preferences and other factors. In the EU ETS, industrial sectors deemed most

at risk of carbon leakage receive the largest shares of free allocation. The Regional Greenhouse Gas and Massachusetts initiatives, which cover the electricity sector, provide minimal or no free permits.

- In the electricity and industry sectors, free allocation weakens the average price signal resulting from ETSSs, creating a gap between the effective average and marginal carbon rates. Even though permit prices in the electricity and industry sectors are respectively of EUR 11.5 per tonne of CO₂ and EUR 27.1 per tonne of CO₂ on average, these sectors are allocated respectively 88% and 84% of their allowances for free.

Contrary to taxes, permit prices can experience significant volatility even over the course of a single year. This volatility can hinder sustained investment in low and zero-carbon technologies.

- Price stability mechanisms exist in many systems, either through direct approaches (e.g. through price floors or ceilings), indirect approaches (e.g. through market stability reserves), or a combination of both.

Since 2021, the energy crisis and Russia's war of aggression against Ukraine have led to policy responses, which have resulted in changes in the energy taxation and carbon pricing landscape in 2022 and 2023. Governments have sought to provide support to their households and firms through reduced energy taxes, among other support measures. Key developments since 2021 have included:

- Despite a high-energy price environment over the period, new ETS initiatives have emerged, mostly in Latin America (e.g. Mexico) and in Asia (e.g. Indonesia).
- ETS permit prices have increased for most systems between 2021 and early 2023, with the increase mainly taking place between 2021 and 2022.
- Tax rates in the road transport sector decreased in real terms, due to rate cuts in response to pre-tax price hikes but also due to a lack of indexation to inflation. Rates decreased more between 2021 and 2022 than between 2022 and 2023.
- Within OECD and G20 countries, the gap between the ECR faced by the road transport sector and that faced by the electricity and industry sectors has lessened between 2021 and 2023, due to a decrease in fuel excise taxes and an increase in permit prices.

Other GHG emissions (methane, nitrous oxide, fluorinated gases and CO₂ emissions from industrial process) can represent a significant share of total emissions in certain countries. This underscores the need to incorporate these emissions in designing pathways to net-zero emissions. Yet, they are the least covered by pricing measures.

- In the 72 countries analysed, other GHGs make up between 8% and 92% of countries' total GHG emissions.
- Effectively addressing these emissions through pricing mechanisms is likely to require the consideration of mitigation policies beyond carbon taxes, which are primarily designed to address CO₂ emissions.
- Uncertainties in the measurement of these other GHGs also present a challenge for the standard monitoring, reporting and verification (MRV) methods used for ETSSs. Measuring the tax base for other GHG emissions is considerably harder than for CO₂ emissions.
- Presently, pricing instruments covering other GHG emissions generally only apply to emissions that are generated by industrial processes, which are partly covered by ETSSs and some carbon taxes.
- In most countries, non-energy related agricultural emissions make up the highest share of other GHG emissions. Finding ways to price these emissions directly or indirectly presents a challenge for the years to come.

Conclusion

Carbon pricing is gaining momentum worldwide and explicit carbon pricing instruments are assuming an increasingly important role. ETSs are progressively expanding in countries where they are already established and being introduced in new countries. ETS permit prices have also demonstrated strong resilience to the energy crisis, sustaining an upward trend in most cases since 2021. Despite this momentum, there are considerable disparities in carbon pricing coverage and price levels across countries and sectors, with over half of global emissions unpriced. Additionally, the recent energy crisis resulted in an unprecedented rise in energy prices, compelling countries to provide support through untargeted measures. These measures, along with a stagnation or cut in nominal fuel and carbon tax rates amidst high inflation have weakened carbon price signals. Building resilience to future shocks and maintaining carbon price signals may warrant a more targeted approach. At the same time, medium and long-term solutions to climate change and to future energy shocks include investments in energy efficiency and low-carbon energy sources and technology. Furthermore, addressing emissions from methane, nitrous oxide, fluorinated gases and process-related CO₂ presents an additional challenge for the years to come.

Note

¹ data-explorer.oecd.org.

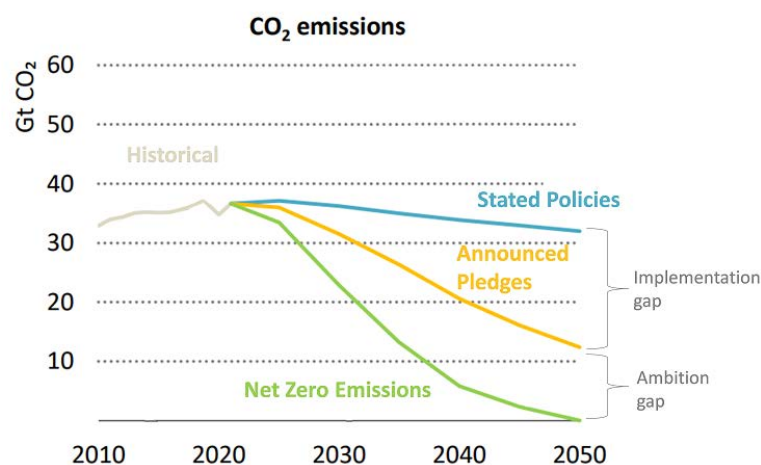
1 Introduction

1.1. Limiting global warming

Attaining the 1.5°C or 2°C goals set out by the Paris Agreement requires immediate and global action, as recently stressed by the 2023 Intergovernmental Panel on Climate Change's Sixth Assessment Report (AR6, IPCC (2023^[1])). By absorbing long-wave infrared radiation reflected by the earth's surface, GHG emissions are directly responsible for climate change through global warming. While this is already causing weather and climate extremes worldwide, increased global warming could ultimately result in crossing tipping points beyond which severe and disruptive changes to human society would become irreversible. To face these threats, the objective set out by the Paris Agreement is to keep the increase in the global average temperature to well below 2°C above pre-industrial levels and to preferably limit the increase to 1.5°C above pre-industrial levels. Even if these goals were to be overshoot, every incremental degree would escalate risks “and projected adverse impacts and related losses and damages” (IPCC, 2023^[1]).

To reach this objective, over 130 countries are seeking to attain carbon neutrality between 2050 and 2060 (Net Zero Tracker, 2023^[2]). However, mitigation efforts should be strengthened, as implementation and ambition gaps remain (IEA, 2022^[3]). These gaps respectively highlight a lack of coherence between current stated policies and announced pledges emission pathways and between the emission pathway implied by announced pledges and the pathway required to reach net zero emissions by mid-century (see Figure 1.1). With current pledges and policies, global warming is set to exceed 2°C (OECD, 2023^[4]; IPCC, 2023^[1]).

Figure 1.1. Implementation and ambition gaps



Note: The Stated Policies Scenario (STEPS) shows the trajectory implied by today's policy settings. The Announced Pledges Scenario (APS) assumes that all aspirational targets announced by governments are met on time and in full, including their long-term net zero and energy access goals. The Net Zero Emissions by 2050 (NZE) Scenario maps out a way to achieve a 1.5 °C stabilisation in the rise in global average temperatures, alongside universal access to modern energy by 2030.

Source: Adapted from Figure 1.19 of IEA (2022^[3]).

Mitigation policy packages vary with many factors, including country circumstances, policy objectives and targeted sectors. Carbon pricing is a core mitigation policy in some countries, while others rely more on non-carbon price-based instruments, e.g. regulation or technology support. This may be due to many factors, including administrative capacity, historical context, the technical and methodological challenges of pricing emissions from dispersed sources, and political constraints. The approach to carbon pricing instruments itself also varies with the mentioned factors shaping more broadly the design of climate change mitigation approaches. For instance, fuel excise taxes are more common than carbon taxes and emissions trading systems and in general were initially introduced to raise revenue (so that aligning them better with climate goals often requires reform). Carbon taxes may require less administrative capacity to implement than ETs, as they are generally based on the carbon content of fuels. On the other hand, ETs, while generally requiring sophisticated monitoring, reporting and verification mechanisms, can face fewer political barriers to implementation.

Climate change is not the only externality to be addressed on the path to net-zero emissions. Other market-failures and externalities such as path-dependency, knowledge spillovers, network externalities or learning-by-doing require additional instruments, e.g. direct research and development (R&D) support or support for infrastructure and technology adoption and deployment. Finally, political barriers to the introduction of carbon mitigation policies and carbon leakage risks underscore the importance of accompanying policies to address distributional, affordability and competitiveness concerns as well as ensure the availability of low-carbon alternatives (Dechezleprêtre et al., 2022^[5]) – to help households and firms adapt in the pathway to net-zero emissions. Evidence also shows that climate policy mixes may be more effective than relying on a single type of policy (Dimanchev and Knittel, 2023^[6]; van der Ploeg and Venables, 2022^[7]). Effective, efficient and broadly supported climate policy therefore requires a policy mix. Accordingly, while this report focusses on carbon pricing instruments across a large set of countries, the OECD's Inclusive Forum on Carbon Mitigation Approaches (IFCMA) will consider the full range of climate mitigation approaches (Box 1.1).

Box 1.1. The OECD Inclusive Forum on Carbon Mitigation Approaches

The OECD launched the Inclusive Forum on Carbon Mitigation Approaches (IFCMA) in June 2022, with a first meeting in February 2023. It brings together a diverse range of countries from around the world, who participate in the initiative on an equal footing.

The IFCMA is designed to facilitate evidence-based mutual learning and inclusive multilateral dialogue on emission reduction efforts around the world. The initiative seeks to facilitate information sharing to take stock of a wide range of carbon mitigation approaches¹ and consider the effectiveness² of mitigation policies and policy packages.

The IFCMA will enable policy makers to showcase good practice. Sharing data and information about the comparative effectiveness of different carbon mitigation approaches will help inform future policy decisions in countries around the world so that mitigation policies that best suit countries' objectives be adopted while being adapted to their circumstances. This will also contribute to a globally more coherent and better coordinated approach to carbon mitigation efforts, which should help reduce global emissions and not just shift emissions to other parts of the world.

Notes:

1. In particular, the forum goes beyond carbon pricing, and considers market-based instruments, such as taxes, subsidies, and tradable schemes, as well as non-market-based instruments, such as regulation and standards.

2. Effectiveness is meant as policies' GHG emissions reduction effect.

Source: <https://www.oecd.org/climate-change/inclusive-forum-on-carbon-mitigation-approaches/>.

The principal appeal of carbon pricing is that in contrast with other mitigation instruments it encourages cost-effective abatement and at the same time it can raise public revenue. Carbon pricing promotes emission cuts up to the point at which marginal abatement costs equal the carbon price. By decentralising abatement decisions, it helps overcome the asymmetry of information between the government and polluters and encourages emissions cuts at the lowest cost. Moreover, carbon pricing creates ongoing mitigation incentives and it reduces rebound effects (Van Dender and Raj, 2022^[8]). Unlike non-pricing instruments, it also raises revenue.

There is growing empirical evidence that carbon pricing is effective in reducing emissions. For example, Leroutier (2022^[9]), Green (2021^[10]), Dussaux (2020^[11]), Andersson (2019^[12]) and Dechezleprêtre et al. (2018^[13]) present results for various sectors and carbon pricing instruments. Recent studies also present carbon dioxide (CO₂) emissions responsiveness results within a unified framework for a large panel of countries, sectors and fuels (Sen and Vollebergh, 2018^[14]; D’Arcangelo et al., 2022^[15]) and find a negative impact of carbon pricing on CO₂ emissions from energy use.

Revenue raised from carbon pricing can be non-negligible. Fetet and Postic (2021^[16]) find that for the fiscal year 2020-21, the revenues generated from carbon taxes and emissions trading systems (ETS) amounted to USD 56.8 billion globally, corresponding to around 0.07% of world GDP in 2020. The recently released International Carbon Action Partnership Emissions Trading Worldwide Status Report (ICAP, 2023^[17]) highlights a record USD 63 billion raised from carbon allowance sales in 2022. Simulations have also been conducted on the revenue impact of carbon pricing reform. For instance, D’Arcangelo et al. (2022^[15]) present the simulated revenue impact of introducing a carbon pricing floor of EUR 60 per tonne of CO₂ and find that this could generate revenues of 2% of countries’ GDP on average. This share would vary depending on countries’ starting points – e.g. their initial carbon price level or the carbon-intensity of the economy. Marten and Van Dender (n.d.^[18]) calculate that in 2015 the revenues generated from effective carbon rates exceeded 1% of GDP in many OECD and G20 countries. They suggest that a carbon price floor of EUR 30 per tonne of CO₂ could more than double such revenues.

Finally, while direct support measures for innovation are essential, evidence also shows that carbon pricing spurs innovation and investment in low-carbon technologies, such as carbon capture and utilisation or electrolytic hydrogen. Hicks (1963^[19]) and recent empirical evidence (Aghion et al., 2016^[20]; Caeli and Dechezleprêtre, 2016^[21]) suggest a positive relationship between carbon pricing and clean innovation. Similarly, evidence shows that when carbon prices are high, the cost of capital for firms is lower (D’Arcangelo et al., 2023^[22]).

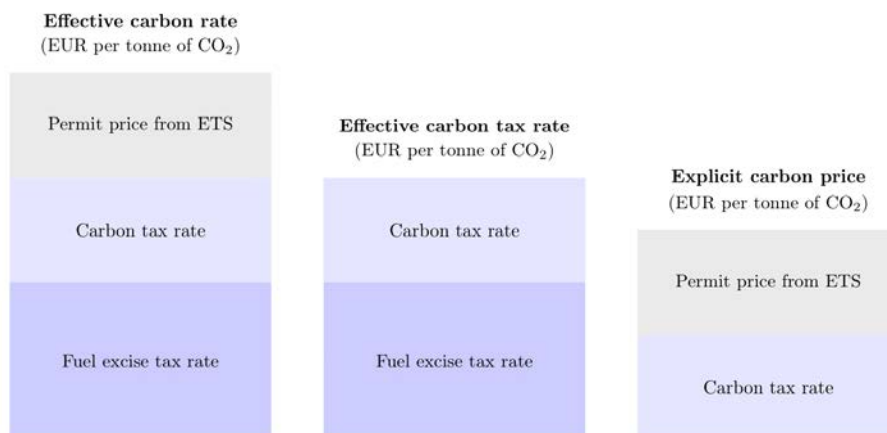
1.2. The OECD Effective Carbon Rates

The OECD ECR database presents carbon prices arising from carbon taxes, ETSs and fuel excise taxes and their mapping to the GHG emissions they cover for each country by sector and fuel.¹ Here, the term “carbon tax” covers the broad range of all taxes that apply to greenhouse gases (including taxes on fluorinated gases (F-gases), for instance). The pricing instruments covered by effective carbon rates either set an explicit price per unit of GHG (e.g., tonnes) or set a price per unit of fuel, which is then proportional to resulting CO₂ emissions.² These instruments encourage a switch away from carbon-intensive fuels.

While this report mainly relies on the effective carbon rates indicator, it also refers to explicit carbon pricing and effective carbon tax rates (see Figure 1.2). Explicit carbon pricing refers to carbon taxation and emissions trading systems. Emissions trading systems are discussed in more detail in Chapter 3. Effective carbon taxes refer to fuel excise taxes and carbon taxes and are discussed in more detail in Chapter 4.

Figure 1.2. Effective carbon rates and sub-indicators

Effective carbon rates and sub-indicators: Effective carbon tax rates and explicit carbon prices.



Note: The term carbon taxes here is used in a broad sense, i.e. they include taxes on any GHG. Permit prices can result from the primary or secondary market. Where possible, the permit price data used in this report is based on the ICAP allowance price explorer, which may rely on either spot or auction prices (see ICAP (2023_[23])).

The database covers CO₂ emissions from energy use from six sectors that together span all energy uses, and covers other GHG emissions (i.e., emissions from methane (CH₄), nitrous oxide (N₂O), F-gases³ and process CO₂ emissions) excluding Land use change and forestry (LUCF)⁴ (Table 1.1). Due to data limitations and to facilitate comparisons with previous ECR vintages, other GHG emissions are not allocated to the six economic sectors but are considered as a seventh sector. Fuels are grouped into 9 categories (Table 1.2). CO₂ emissions in the ECR database are based on energy use data from the International Energy Agency's World Energy Statistics and Balances (IEA, 2020_[24]). Other GHG emissions are sourced from the CAIT database (Climate Watch, 2022_[25]).

Table 1.1. ECR sectors and users

Sector	Definition	Energy users
Road transport	Fossil fuel CO ₂ emissions from all primary energy used in road transport.	Road
Electricity	Fossil fuel CO ₂ emissions from primary energy used to generate electricity (excl. auto-producer electricity plants which are assigned to industry), including for electricity exports. Electricity imports are excluded.	Main activity producer electricity plants
Industry	Fossil fuel CO ₂ emissions from primary energy used in industrial facilities (incl. district heating and auto-producer electricity plants).	Adjusted losses in energy distribution, transmission and transport; Adjusted energy industry own use; Adjusted transformation processes; Auto-generation of electricity; Chemical and petrochemical; Construction; Food and tobacco; Industry not elsewhere specified; Iron and steel; Machinery; Mining and quarrying; Non-ferrous metals; Non-metallic minerals; Paper, pulp and print; Solid heat; Textile and leather; Transport equipment; Wood and wood products
Buildings(*)	Fossil fuel CO ₂ emissions from primary energy used by households, commercial and public services for activities other than electricity generation and transport.	Commercial and public services; Final consumption not elsewhere specified; Residential

Off-road transport	Fossil fuel CO ₂ emissions from all primary energy used in off-road transport (incl. pipelines, rail transport, aviation and maritime transport). Fuels used in international aviation and maritime transport are not included.	Domestic aviation; Domestic navigation; Pipeline transport; Rail; Transport not elsewhere specified
Agriculture & fisheries	Fossil fuel CO ₂ emissions from primary energy used in agriculture, fisheries and forestry for activities other than electricity generation and transport.	Agriculture; Fishing
Other GHG (excl. LUCF)	All other GHG emissions include methane, nitrous oxide from agriculture; fugitive emissions from oil, gas and coal mining activities; waste; non-fuel combustion CO ₂ emissions from industrial processes (mainly cement production), N ₂ O and CH ₄ emissions from industrial processes and F-gas emissions. Excludes LUCF emissions. Excludes CO ₂ emissions from fuel combustion which are already reported in the agriculture & fisheries sector.	n.a.

Note: Estimates of primary energy use are based on the territoriality principle, and include energy sold in the territory of a country but potentially used elsewhere (e.g. because of fuel tourism in road transport). Own classification based on information on energy flows contained in the IEA's extended world energy balances (IEA, 2020^[26]) and "other GHG" reported in the Climate Watch dataset (2022^[25]).

(*) In previous Effective Carbon Rates editions, this sector was referred to as "Residential and Commercial".

Source: OECD (2016^[27]) and (OECD, 2022^[28]).

Table 1.2. Fuel category breakdown

Energy type	Fuel category	Energy Products
Fossil fuels	Coal and other solid fossil fuels	Anthracite; Bitumen; Bituminous coal; Brown coal briquettes; Oven coke; Coking coal; Gas coke; Lignite; Oil shale; Patent fuel; Peat; Peat products; Petroleum coke; Sub-bituminous coal
	Fuel oil	Fuel oil
	Diesel	Gas/diesel oil excluding biofuels
	Kerosene	Jet kerosene; Other kerosene
	Gasoline	Aviation gasoline; Jet gasoline; Motor gasoline
	LPG	Liquefied Petroleum Gas
	Natural gas	Natural gas
	Other fossil fuels and non-renewable waste	Additives; Blast furnace gas; Coal tar; Coke oven gas; Converter gas; Crude oil; Ethane; Gas works gas; Lubricants; Naphtha; Natural gas liquids; Other hydrocarbons; Other oil products; Paraffin waxes; Refinery feedstocks; Refinery gas; White and industrial spirit; Industrial waste; Non-renewable municipal waste
Biofuels	Biofuels	Bio jet kerosene; Biodiesels; Biogases; Biogasoline; Charcoal; Municipal waste (renewable); non-specified primary biofuels and waste; Other liquid biofuels; Primary solid biofuels

Note: Energy products are defined as in IEA (2020^[26]). Emissions from the combustion of biofuels are not included in the main analysis of this edition (Appendix A presents results including them).

Source: OECD (2019^[33]).

The ECR database covers pricing instruments that apply to a base that is directly proportional to energy use or GHG emissions. It therefore excludes taxes and fees that are only partially correlated with energy use or GHG emissions. These include vehicle purchase taxes, registration or circulation taxes, and taxes that are directly levied on air pollution emissions (e.g. the Danish tax on SO_x or the Swedish NO_x fee). Production taxes on the extraction or exploitation of energy resources (e.g. severance taxes on oil extraction) are not within the scope of instruments covered either, as supply-side measures are not directly linked to domestic energy use or emissions.

The database covers specific taxes (i.e. taxes that apply per unit of good as opposed to ad-valorem taxes, which depend on the good's price) taxes that affect the relative price of carbon-intensive goods. In line with

these two criteria, value added taxes (VAT) or sales taxes are not accounted for. Indeed, in principle VAT applies equally to a wide range of goods, so does not change the relative prices of products and services (i.e. it does not make carbon-intensive goods and services more expensive relative to cleaner alternatives). In practice, differential VAT treatment and concessionary rates may target certain forms of energy use, thereby changing their relative price (OECD, 2015^[29]). However, quantifying the effects of differential VAT treatment is beyond the scope of the database. Such an exercise would entail extensive price information, which is generally not available for all energy products. Also, electricity excise taxes do not treat fossil fuels in a differential manner as compared to clean sources and are therefore not part of the ECR indicator.

The ECR database includes support measures for fossil fuel consumption that are delivered through the tax code, such as excise or carbon tax exemptions, rate reductions and refunds, which are pervasive in energy tax and carbon pricing systems. This is different from the Net ECR (nECR) database, which includes also fossil fuel subsidies that lower pre-tax prices. Indeed, the availability of preferential treatment varies substantially across countries, and even within a country such preferential treatment frequently changes over time. As a result, simply comparing statutory rates (also sometimes referred to as standard or advertised rates) across countries and time would be misleading. More precisely, certain energy users or GHG emitters frequently enjoy preferential treatment that effectively reduces prices on energy or emissions. Therefore, effective tax rates measured by the database are adjusted accordingly irrespective of whether countries report such policy measures as tax expenditures (OECD, 2022^[28]).⁵

Data on ETS permit prices and coverage is originally gathered for the Effective Carbon Rates database. The Effective Carbon Rates database then builds on the Taxing Energy Use database for fuel excise tax and carbon tax data. The first publication of Effective Carbon Rates describes the methodology for matching ETS permit prices and coverage with taxes (OECD, 2016^[27]).

The recently established OECD Series on Carbon Pricing and Energy Taxation brings together the Effective Carbon Rates and Taxing Energy Use (TEU) databases with the report Pricing Greenhouse Gas Emissions (PGHG). The interlinkages, similarities, and differences between these three reports are further explained in Box 1.2.

Box 1.2. Understanding the relationship between the Effective Carbon Rates and Taxing Energy Use models and processes: An alternating relay for two

The recently established OECD Series on Carbon Pricing and Energy Taxation brings together the ECR and TEU databases with the report PGHG.

Previously, TEU focused on gathering and calculating the effective tax rates exclusively applied to energy¹ and its corresponding carbon dioxide emissions base. The analysis did not include emissions trading systems. Nonetheless, its merit lay in the dual perspective on energy and carbon emissions and the provision of up-to-date tax rates and instruments. The successor to TEU, PGHG, addressed this gap, by incorporating estimates from the already established Effective Carbon Rates database including reconciling emissions bases subject to ETSS, energy and carbon taxes.

More specifically, ECR builds on the effective carbon tax rate indicator and calculates ETS coverage estimates, typically starting from granular verified emissions data at facility level. To accurately attribute verified emissions data to (sub)sectors, an important requirement is to match data on the energy base (representing the main sources of GHG emissions especially ETS covered emissions) to the verified ETS emissions in the same year. This approach allows for a consolidated emissions base and computing reliable ETS coverage estimates. There is also a feedback loop between the estimation of ETS emissions coverage and tax emissions coverage estimates for cases where ETS and taxes are complementary. Currently, official energy and CO₂ emissions from energy datasets have a lag of two years.²

This edition of Effective Carbon Rates marks the first time that consolidated ETS coverage estimates are made available the same year that verified emissions and CO₂ emissions from energy use are released. It also discusses pricing and emissions coverage of other GHGs in detail, improves estimates on free allocation and (sub)sectors and even provides a within current year direction of travel for ECRs incorporating recent tax changes in transport, the latest permit prices and new systems.

Behind the scenes, there is still value in running two separate cycles of the resource intensive data collection and update processes for TEU and ECR, with all the new features (extension to fossil fuel subsidies, covering all greenhouse gases, increasing number of countries and carbon pricing instruments). The recent PGHG and the current report set the bar for the coming years.

Notes:

1. Specifically, energy tax rates included those applied to clean energy sources and electricity output.

2. For example, the IEA releases data on 2021 in the course of 2023, in April for OECD and most G20 countries, and during August for global coverage.

Source: Authors

1.3. Scope of the present edition

This edition first presents ECRs in 2021 and details on the “other GHG” sector, which was included for the first time in the Pricing Greenhouse Gas Emissions publication in 2022. It then focuses on emissions trading systems in 2021 and developments therein over the course of 2022 and 2023, with discussions and evidence on free allocation and price stability mechanisms. Finally, it analyses recent developments in road transport fuel excise and carbon taxes amid the energy crisis.

The ECR indicator for 2021 covers 72 countries⁶, which together account for about 80% of global GHG emissions (excluding emissions from LUCF). This edition includes the 71 countries covered in the 2022 Pricing Greenhouse Gas Emissions report (OECD, 2022^[28]) and an additional country: Kazakhstan.⁷ The 71 countries are made up of all 45 OECD and G20 countries other than Saudi Arabia and 26 other countries. Eleven of these 26 countries are in Africa (Burkina Faso, Côte d'Ivoire, Egypt, Ethiopia, Ghana, Kenya, Madagascar, Morocco, Nigeria, Rwanda, Uganda), eight in Latin America and the Caribbean (Dominican Republic, Ecuador, Guatemala, Jamaica, Panama, Paraguay, Peru, Uruguay), five are in Asia (Bangladesh, Kyrgyzstan, Malaysia, Philippines, Sri Lanka) and two in Europe (Cyprus, Ukraine).

The term “total emissions” is used to refer to GHG emissions from the 72 countries considered in this report. Effective carbon rates in 2021 consist of tax rates as of 1 April 2021 and permit prices from ETSS averaged over 2021. The coverage of emissions trading systems is estimated based on data by the authorities governing the respective systems (see Chapter 3 for details on emissions trading systems). CO₂ emissions from energy use data is for 2021 when available, namely OECD and G20 countries plus Cyprus and Kazakhstan and for 2018 elsewhere. It is based on energy use data from the International Energy Agency's World Energy Statistics and Balances (IEA, 2023^[30]). Other GHG emissions data is for 2018 and is from the CAIT database (Climate Watch, 2022^[25]). Official exchange rate and inflation data are used to express prices in constant terms when required and noted.⁸

This edition presents results excluding biofuel emissions, to stay consistent with the approach taken in earlier vintages. Previous editions of *Effective Carbon Rates* and *Taxing Energy Use*, for which the emissions base consisted in CO₂ emissions from energy use only, relied on the “combustion approach” as opposed to a “life-cycle approach” (see Annex 3.A of OECD (2018^[31]) for a discussion on the implications of the combustion approach), and they hence included emissions from the combustion of biofuels. In line with the latest *Pricing Greenhouse Gas Emissions* report, this edition presents results that exclude

emissions from the combustion of biofuels, consistent with the fact that the other GHG emissions (emissions from CH₄, N₂O, F-gases and process CO₂ emissions) that were added to the emissions base exclude LUCF. This should not be interpreted as a view in favour of one approach over the other but rather as a consistency measure, and results including emissions from the combustion of biofuels are presented in Annex A as a memo item. Biofuel taxation is further discussed in Box 1.3.

Box 1.3. Pricing CO₂ emissions from biofuel use

While not all biofuels are carbon neutral, they can be. When combusted, biofuels release CO₂. However, as discussed in OECD (2019^[32]), sustainably sourced biofuels may be carbon-neutral over the lifecycle because before being burnt, feedstocks have previously absorbed an equivalent amount of CO₂ from the atmosphere. To what extent biofuel use is carbon-neutral over the lifecycle is an empirical question.

CO₂ emissions from biofuel combustion are not explicitly reported in the greenhouse gas inventories submitted under the UN Framework Convention on Climate Change (UNFCCC). The guidelines of the UN Intergovernmental Panel on Climate Change (IPCC) require accounting for emissions and sinks from biofuels as net changes in carbon stocks under the annual reporting of Land Use, Land Use Change and Forestry.

Most governments do not tax biofuels outside the road transport sector. Instead of taxation, they generally use sustainability standards for biofuels. This requires gathering reliable data on their sustainability. This is a challenging task, and such data is often lacking (Jeswani, Chilvers and Azapagic, 2020^[33]; Baudry et al., 2017^[34]). The European Union (EU) revised Renewable Energy Directive, RED II¹ provides detailed sustainability and greenhouse gas emissions saving criteria (Article 29) and guidelines for the calculation of the greenhouse gas impact of biofuels (Article 31). It also defines the term “advanced biofuels” to mean biofuels that are produced from a specific list of feedstocks.

Some governments have attempted to design comprehensive biofuel taxation. For example, the Finnish carbon tax for transport fuels is based on lifecycle CO₂ emissions – a unique feature in the world today (OECD, 2021^[35]). Under the Finnish tax, biofuels are classified under three categories: i) biofuels that do not meet sustainability criteria are subject to the same carbon tax as fossil fuels; ii) sustainable first-generation biofuels are subject to 50% of the rate which applies to equivalent fossil fuels; and iii) sustainable second-generation biofuels are exempt. In 2019, the methodology based on lifecycle carbon emissions was extended to fuels for heating and machinery. While also requiring a comprehensive assessment of biofuel sustainability, this kind of category-dependent tax rate constitutes a novel approach to taxing biofuels, which encompasses lifecycle emissions. Germany has also included some biofuels in its newly introduced national emissions trading system (nEHS) which applies to transport and heating fuels. The biofuels included are those that do not meet sustainability criteria set out in national regulations.² In 2021, the proposed revision to the EU Energy Taxation Directive (ETD) considered different minimum taxation rates for non-sustainable, sustainable but not advanced and advanced biofuels.

Alternatively, taxing the CO₂ emissions from the combustion of woody biomass could be combined with simultaneously rewarding forest owners for the carbon they store. This, along with the trade-offs between forest harvesting levels and the forests’ potential as a carbon sink,³ is discussed in Kooten, Binkley and Delcourt (1995^[36]) and OECD (2021^[35]). The design of such a subsidy and tax system, however, would require careful consideration of incidence. Indeed, the subsidy on the upstream actor of the supply chain (e.g. the forest owner) or the tax on the downstream actor (the biofuel user) could pass-through to the other, which might mute or over-emphasise price signals.

Moreover, the prevalence of forestry offset provisions in ETSs (including California, multiple Chinese pilots, New Zealand, Quebec, Regional Greenhouse Gas Initiative (RGGI))⁴ requires careful consideration by governments. If the forests cannot be logged, such provisions may stand alone. However, if over time forests that were once used as offsets can be used as woody biomass, the question of the non-taxation of combustion emissions from such biofuels arises, given that the initial part of the lifecycle of these biofuels has already been positively rewarded. New Zealand has an approach that imposes ongoing, indefinite liability for any reversal of credited removals. Maintaining liability for reversals over an indefinite period provides an incentive to protect carbon sinks over the long term. New Zealand employs this approach within its Nationally Determined Contribution (NDC) and domestic ETS. For example, in the New Zealand system carbon stocks (including reversals) are monitored and accounted for over time both within New Zealand's NDC and domestic ETS. Liability to surrender ETS units in the event of reversal generally remains with the landowner.

Finally, the increased use of biofuels raises additional concerns, which go beyond climate change. Harvesting raises issues for biodiversity, soil health and water quality, and biofuel combustion may worsen local air pollution (different from greenhouse gas emissions), especially from particulate matter (PM) and nitrogen oxides (NOx) emissions, which is not compensated for from a lifecycle point of view. Local air pollution, in turn, can have substantial environmental, health and economic costs (OECD, 2020^[37]; OECD, 2023^[38]).

Notes:

1. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG, as accessed on 06 June 2023.
 2. These are sustainability criteria set out in national Regulations, transposing the "European Renewable Energy Directives 2009/28/EC" and "2018/2001" (ICAP, 2023^[39]). While biofuels present an important share of energy use in the German buildings sector (about 26%) and a non-negligible share in the road transport sector (about 5.5%), most of it meets the sustainability criteria.
 3. The EU revised Renewable Energy Directive also seeks to address such trade-offs: sustainability criteria were revised to account for the negative direct impact that the production of biofuels may have because of indirect land use change (https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biofuels_en, as accessed on 30 May 2022). This occurs when biofuel production leads to the extension of agricultural land into non-crop land such as forests, wetlands and peatlands, which constitute high carbon stock.
 4. See (La Hoz Theuer et al., 2023^[40]) for an in-depth analysis of carbon offset use in ETSs.
- Source: Based on Box 4.2 of OECD (2023^[41]).

This report uses the same benchmark rates as those in previous *Effective Carbon Rates* editions and in the latest *Pricing Greenhouse Gas Emissions* report to assess carbon pricing progress and alignment with net zero goals. The carbon benchmark of EUR 30 is a minimum price level to start triggering meaningful abatement efforts today. The carbon benchmark of EUR 60 is a low-end estimate of the carbon prices that would be needed by 2030 for consistency with net-zero emissions targets, while EUR 120 per tonne is a mid-range estimate of carbon prices required by 2030 (OECD, 2021^[42]; Kaufman et al., 2020^[43]; European Commission, 2018^[44]). These are benchmark rates that adopt a target-oriented approach as opposed to an external cost pricing approach (e.g. the social cost of carbon or SCC), and they depend on the support of policy measures implemented beyond carbon pricing (Stern et al., 2022^[45]). Carbon pricing pathways which take a whole-of economy approach as opposed to a pure external cost pricing perspective are increasingly prevalent. These pathways account for assumptions regarding the evolution of countries' economic conditions (e.g. growth), the introduction of new technologies and additional non-carbon pricing measures (see e.g. IPCC (2018^[46]), IEA (2021^[47]), Quinet (2019^[48]), Climate Change Committee (2020^[49]; 2020^[50])). Estimates of carbon prices required to reach net zero objectives can be even higher, reaching for example EUR 250 per tonne of CO₂ by 2030 (European Investment Bank Group, 2020^[51]), but such estimates consider carbon pricing as the only climate mitigation instrument.

References

- Aghion, P. et al. (2016), “Carbon Taxes, Path Dependency, and Directed Technical Change: Evidence from the Auto Industry”, *Journal of Political Economy*, Vol. 124/1, pp. 1-51, <https://doi.org/10.1086/684581>. [20]
- Andersson, J. (2019), “Carbon Taxes and CO2 Emissions: Sweden as a Case Study”, *American Economic Journal: Economic Policy*, Vol. 11/4, pp. 1-30, <https://doi.org/10.1257/pol.20170144>. [12]
- Baudry, G. et al. (2017), “The challenge of measuring biofuel sustainability: A stakeholder-driven approach applied to the French case”, *Renewable and Sustainable Energy Reviews*, Vol. 69, pp. 933-947, <https://doi.org/10.1016/j.rser.2016.11.022>. [34]
- Calel, R. and A. Dechezleprêtre (2016), “Environmental Policy and Directed Technological Change: Evidence from the European Carbon Market”, *Review of Economics and Statistics*, Vol. 98/1, pp. 173-191, https://doi.org/10.1162/rest_a_00470. [21]
- CCC (2020), *The Sixth Carbon Budget - Methodology Report*. [50]
- CCC (2020), *The Sixth Carbon Budget - The UK's path to Net Zero*. [49]
- Climate Watch (2022), <https://www.climatewatchdata.org>. [25]
- D’Arcangelo, F. et al. (2023), “Corporate cost of debt in the low-carbon transition: The effect of climate policies on firm financing and investment through the banking channel”, *OECD Economics Department Working Papers*, No. 1761, OECD Publishing, Paris, <https://doi.org/10.1787/35a3fbb7-en>. [22]
- D’Arcangelo, F. et al. (2022), “Estimating the CO2 emission and revenue effects of carbon pricing: New evidence from a large cross-country dataset”, *OECD Economics Department Working Papers*, No. 1732, OECD Publishing, Paris, <https://doi.org/10.1787/39aa16d4-en>. [15]
- Dechezleprêtre, A. et al. (2022), “Fighting climate change: International attitudes toward climate policies”, *OECD Economics Department Working Papers*, No. 1714, OECD Publishing, Paris, <https://doi.org/10.1787/3406f29a-en>. [5]
- Dechezleprêtre, A., D. Nachtigall and F. Venmans (2018), “The joint impact of the European Union emissions trading system on carbon emissions and economic performance”, *OECD Economics Department Working Papers*, No. 1515, OECD Publishing, Paris, <https://doi.org/10.1787/4819b016-en>. [13]
- Dimanchev, E. and C. Knittel (2023), “Designing climate policy mixes: Analytical and energy system modeling approaches”, *Energy Economics*, Vol. 122, p. 106697, <https://doi.org/10.1016/j.eneco.2023.106697>. [6]
- Dussaux, D. (2020), “The joint effects of energy prices and carbon taxes on environmental and economic performance: Evidence from the French manufacturing sector”, *OECD Environment Working Papers*, No. 154, OECD Publishing, Paris, <https://doi.org/10.1787/b84b1b7d-en>. [11]
- European Commission (2018), “A Clean Planet for all - A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy”, *COM(2018) 773 final*, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52018DC0773>. [44]

- European Investment Bank Group (2020), "Climate Bank Roadmap. 2021-2025", [51]
https://www.eib.org/attachments/thematic/eib_group_climate_bank_roadmap_en.pdf.
- Fetet, S. and M. Postic (2021), *Global carbon accounts in 2021*, [16]
<https://www.i4ce.org/download/global-carbon-account-in-2021/>.
- Green, J. (2021), "Does carbon pricing reduce emissions? A review of ex-post analyses", [10]
Environmental Research Letters, Vol. 16/4, <https://doi.org/10.1088/1748-9326/abdae9>.
- Hicks, J. (1963), *The Theory of Wages*, Palgrave Macmillan UK, London, [19]
<https://doi.org/10.1007/978-1-349-00189-7>.
- ICAP (2023), *Documentation Allowance Price Explorer*, [23]
<https://icapcarbonaction.com/en/documentation-allowance-price-explorer> (accessed on 30 May 2023).
- ICAP (2023), "Emissions Trading Worldwide: Status Report 2023", *Berlin: International Carbon Action Partnership*, [39]
https://icapcarbonaction.com/system/files/document/ICAP%20Emissions%20Trading%20Worldwide%202023%20Status%20Report_0.pdf.
- ICAP (2023), "Emissions Trading Worldwide: Status Report 2023.", *Berlin: International Carbon Action Partnership*. [17]
- IEA (2023), "Extended world energy balances", *IEA World Energy Statistics and Balances* [30]
(database), <https://doi.org/10.1787/data-00513-en> (accessed on 28 March 2023).
- IEA (2022), "World Energy Outlook 2022", *IEA, Paris*, License: CC BY 4.0 (report); CC BY NC [3]
SA 4.0 (Annex A), <https://www.iea.org/reports/world-energy-outlook-2022>.
- IEA (2021), *Net Zero by 2050 - A Roadmap for the Global Energy Sector*. [47]
- IEA (2020), *Extended world energy balances (database)*, [24]
<http://www.iea.org/statistics/topics/energybalances>.
- IEA (2020), "World Energy Balances - 2020 Edition - Database documentation", [26]
<https://www.iea.org/subscribe-to-data-services/world-energy-balances-and-statistics>.
- IPCC (2023), "Synthesis Report of the IPCC Sixth Assessment Report (AR6)", [1]
https://report.ipcc.ch/ar6syr/pdf/IPCC_AR6_SYR_LongerReport.pdf.
- IPCC (2018), *Global Warming of 1.5°C*. [46]
- Jeswani, H., A. Chilvers and A. Azapagic (2020), "Environmental sustainability of biofuels: a review", *Proceedings of the Royal Society A: Mathematical, Physical and Engineering Sciences*, Vol. 476/2243, <https://doi.org/10.1098/rspa.2020.0351>. [33]
- Kaufman, N. et al. (2020), "A near-term to net zero alternative to the social cost of carbon for setting carbon prices", *Nature Climate Change*, Vol. 10/11, pp. 1010-1014, [43]
<https://doi.org/10.1038/s41558-020-0880-3>.
- Kooten, G., C. Binkley and G. Delcourt (1995), "Effect of Carbon Taxes and Subsidies on Optimal Forest Rotation Age and Supply of Carbon Services", *American Journal of Agricultural Economics*, Vol. 77/2, pp. 365-374, <https://doi.org/10.2307/1243546>. [36]

- La Hoz Theuer, S. et al. (2023), "Offset Use Across Emissions Trading Systems", *Berlin: ICAP*. [40]
- Leroutier, M. (2022), "Carbon Pricing and Power Sector Decarbonisation: Evidence from the UK", *Journal of Environmental Economics and Management*, Vol. 111, <https://doi.org/10.1016/j.jeem.2021.102580>. [9]
- Net Zero Tracker (2023), *Data Explorer*, <https://zerotracker.net/>. [2]
- OECD (2023), *Air pollution effects* (indicator), <https://doi.org/10.1787/573e3faf-en> (accessed on 4 May 2023). [38]
- OECD (2023), *Net Zero+: Climate and Economic Resilience in a Changing World*, OECD Publishing, Paris, <https://doi.org/10.1787/da477dda-en>. [4]
- OECD (2023), *Reform Options for Lithuanian Climate Neutrality by 2050*, OECD Publishing, Paris, <https://doi.org/10.1787/0d570e99-en>. [41]
- 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>. [28]
- OECD (2021), *Effective Carbon Rates 2021: Pricing Carbon Emissions through Taxes and Emissions Trading*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, <https://doi.org/10.1787/0e8e24f5-en>. [42]
- OECD (2021), *OECD Environmental Performance Reviews: Finland 2021*, OECD Environmental Performance Reviews, OECD Publishing, Paris, <https://doi.org/10.1787/d73547b7-en>. [35]
- OECD (2020), *Environment at a Glance 2020*, OECD Publishing, Paris, <https://doi.org/10.1787/4ea7d35f-en>. [37]
- OECD (2019), *Taxing Energy Use 2019: Using Taxes for Climate Action*, OECD Publishing, Paris, <https://doi.org/10.1787/058ca239-en>. [32]
- OECD (2018), *Effective Carbon Rates 2018: Pricing Carbon Emissions Through Taxes and Emissions Trading*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, <https://doi.org/10.1787/9789264305304-en>. [31]
- OECD (2016), *Effective Carbon Rates: Pricing CO2 through Taxes and Emissions Trading Systems*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, <https://doi.org/10.1787/9789264260115-en>. [27]
- OECD (2015), *Taxing Energy Use 2015: OECD and Selected Partner Economies*, OECD Publishing, Paris, <https://doi.org/10.1787/9789264232334-en>. [29]
- OECD (n.d.), *OECD Taxation Working Papers*, OECD Publishing, Paris, <https://doi.org/10.1787/22235558>. [18]
- Quinet, A. (2019), *La valeur de l'action pour le climat - Une valeur tutélaire du carbone pour évaluer les investissements et les politiques publiques*. [48]
- Sen, S. and H. Vollebergh (2018), "The effectiveness of taxing the carbon content of energy consumption", *Journal of Environmental Economics and Management*, Vol. 92, pp. 74-99. [14]

- Stern, N. et al. (2022), "A Social Cost of Carbon consistent with a net-zero climate goal", *Roosevelt Institute*, https://rooseveltinstitute.org/wp-content/uploads/2022/01/RI_Social-Cost-of-Carbon_202201-1.pdf. [45]
- Van Dender, K. and A. Raj (2022), "Progressing carbon pricing - a Sisyphean task?", *Gestion & Finances Publiques* 7, pp. 43-57, <https://doi.org/10.3166/gfp.2022.ns.010>. [8]
- van der Ploeg, F. and A. Venables (2022), *Radical climate policies*, University of Oxford, <https://ora.ox.ac.uk/objects/uuid:75d49b40-396d-454d-a07f-59b452de6e51>. [7]

Notes

¹ Effective Carbon Rates account for fossil fuel support when delivered through preferential excise or carbon tax rates, so they are always greater than or equal to zero. However, they do not account for government measures that decrease pre-tax prices of fossil fuels. Net Effective Carbon Rates (Garsous et al., 2023^[55]) account for a broader range of fossil fuel subsidies but are not included in this edition.

² In the latter case, rates are typically expressed in common commercial units (e.g., as a price per kilogram for solid fuels, per litre for liquid fuels, per cubic metre for gaseous fuels). These can be converted into a price per energy unit (e.g. GJ) using calorific factors from the IEA World Energy Statistics and Balances (IEA, 2023^[30]) and then into a price per tonne of CO₂ using IPCC emissions conversion factors (Intergovernmental Panel on Climate Change's Guidelines for National Greenhouse Gas Inventories (IPCC, 2006^[53]), volume 2). More precisely, such calculations make use of the fact that CO₂ emissions are constant per unit of fuel (e.g., one litre of diesel produces on average around 2.76 kilograms of CO₂). This applies to fuel excise taxes but also to many carbon taxes. See OECD (2019^[33]), Chapters 1 and 3, for further details.

³ HFCs, PFCs, and SF₆.

⁴ As (OECD, 2022^[28]), this report uses the abbreviation LUCF (as opposed to the term LULUCF, i.e. land use, land-use change, and forestry), to emphasise that the underlying GHG emissions data is sourced from the CAIT dataset (Climate Watch, 2022^[25]), which does not rely on countries' official inventories reported to the UNFCCC.

⁵ This represents a different approach from the OECD's Inventory of Fossil Fuel Support (2023^[54]). See Box 1.2 of (OECD, 2022^[28]) for additional details on the difference in approaches.

⁶ All aggregate values involving G20 countries include the Russia Federation.

⁷ Kazakhstan was the only country with an ETS in 2021 which was not covered in OECD (2022^[28]).

⁸ Where OECD exchange rate period averages were not available, they were supplemented using IMF International Financial Statistics. Inflation data gaps were supplemented using the World Bank's World Development Indicators Consumer Prices. In the case of Argentina and Kazakhstan, the GDP deflator was used as an approximation for inflation. Remaining missing values were filled with the most recent available values.

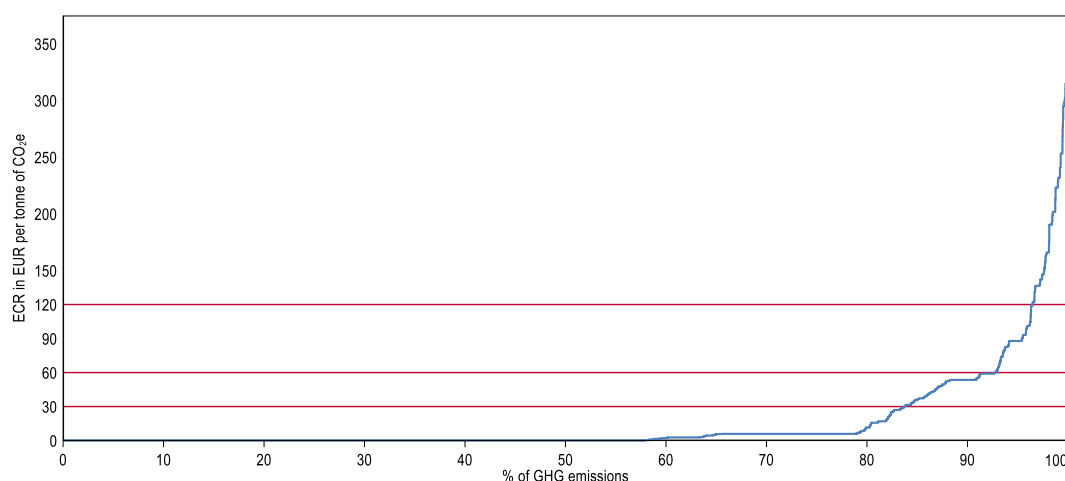
2 Effective Carbon Rates in 2021

2.1. Effectives Carbon Rates in 2021

In 2021, 42% of the little over 40 billion tonnes of GHG emissions were priced in the 72 countries considered in this report (Figure 2.1). The distribution is skewed, with about 16% of GHG emissions priced over the EUR 30 benchmark. About 7% of emissions are priced at EUR 60 or more and almost 4% are priced at EUR 120 or more.

Figure 2.1. Distribution of Effective Carbon Rates

2021, 72 countries



Note: The breakdown of percentiles by type of pricing instrument is presented in Annex 2.A (Annex Figure 2.A.1). The equivalent figure when accounting for CO₂ emissions from biofuel combustion is presented in Annex A.

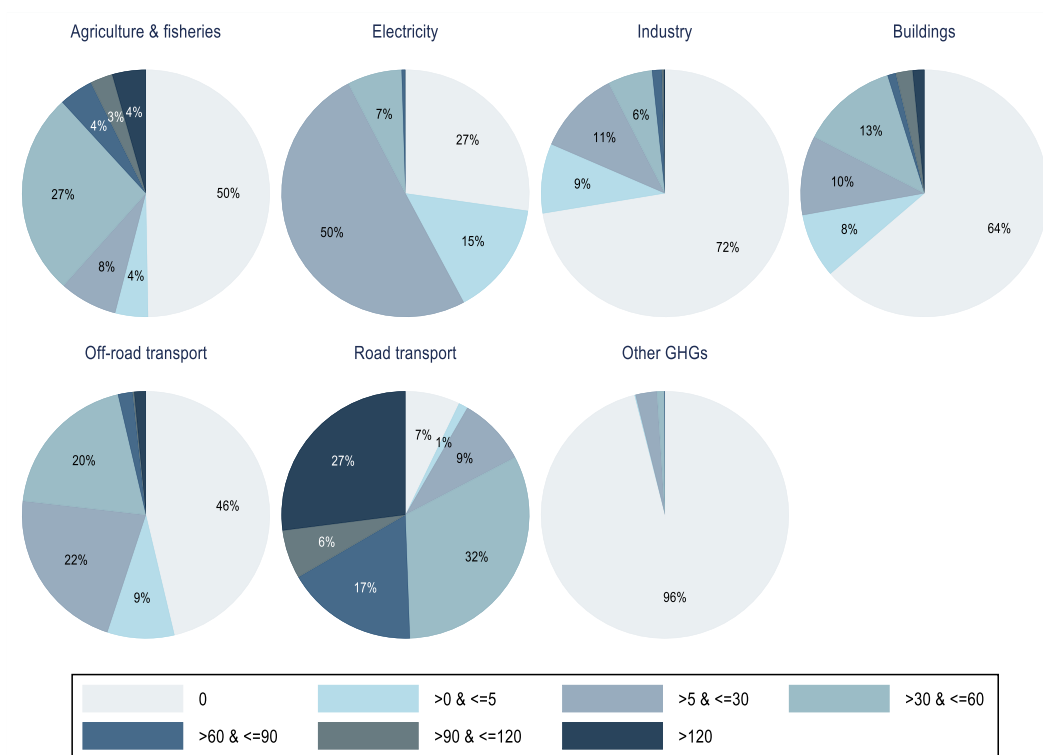
StatLink  <https://stat.link/y8sm1g>

The distribution of ECRs is heterogenous across sectors, with the road transport sector facing the highest rates, followed by the electricity and off-road transport sectors, and the majority of other GHG emissions (methane – CH₄ –, nitrous oxide – N₂O –, fluorinated gases – F-gases – and carbon dioxide – CO₂ from process) facing no carbon price (Figure 2.2). Rates above EUR 60 and EUR 120 per tonne of CO₂ mostly occur in the road transport sector. However, high taxation rates in this sector may also reflect the pricing of other externalities caused by road transport, such as air pollution, accidents, congestion and noise,¹ or can reflect revenue raising objectives. Despite the industry sector contributing more than a quarter of total emissions (Figure 2.3), 72% of emissions in that sector remain unpriced. Only 7.5% of emissions in the industry sector are priced above the EUR 30 benchmark. Almost three quarters (73%) of the electricity sector emissions face a positive carbon price, with half of ECRs in the sector between EUR 5 and 30 per tonne of CO₂ and a little over 7% above EUR 30 per tonne of CO₂. About two thirds (64%) of the buildings

sector emissions are unpriced, with about 17% of emissions covered by ECRs over EUR 30 per tonne of CO₂. Other GHGs face the lowest ECRs, with 96% of emissions unpriced.

Figure 2.2. Proportion of CO₂e emissions priced at different ECR levels by sector

2021, 72 countries



Note: Other GHG emissions refer to emissions from methane (CH₄), nitrous oxide (N₂O), F-gases and process CO₂ emissions excluding LUCF. The equivalent figure when accounting for CO₂ emissions from biofuel combustion is presented in Annex A.

StatLink  <https://stat.link/2onywz>

Differences in average price levels between sectors can be related to differences in pricing instruments used to cover their emissions (Figure 2.3), to the degree of coverage, and to differences in fuel use across sectors² (Figure 2.4). ECRs are highest in sectors where emissions are predominantly covered by fuel excise taxes – that is, in the road transport, and to a lesser extent in the agriculture and fisheries, off-road transport and buildings sectors. In those sectors, average fuel excise tax rates stand at respectively EUR 86, EUR 25, EUR 15 and EUR 10 per tonne of CO₂. The lower ECRs are observed for sectors where emissions are mostly covered by emissions trading systems (ETs), the electricity and industry sectors (their average ECRs stand at respectively EUR 7.5 and EUR 6 per tonne of CO₂). This is in part because fuel excise taxes are more prevalent than ETs as a carbon pricing instrument and because when fuel excise taxes are used, they tend to cover a larger proportion of a sector's emissions than ETs. Chapter 3 shows that average ECRs are higher in the electricity and industry sectors when restricting attention to countries that have an ETs.

Explicit pricing instruments are being used to price emissions in all sectors (Figure 2.3). Emissions trading systems are mostly used in the electricity and industry sectors, accounting for 86% and 70% of the respective sectors' average ECRs: average permit prices in these sectors stand at respectively EUR 6.5 and EUR 4 per tonne of CO₂. ETs are the main instrument that covers other GHG emissions (3.8%),

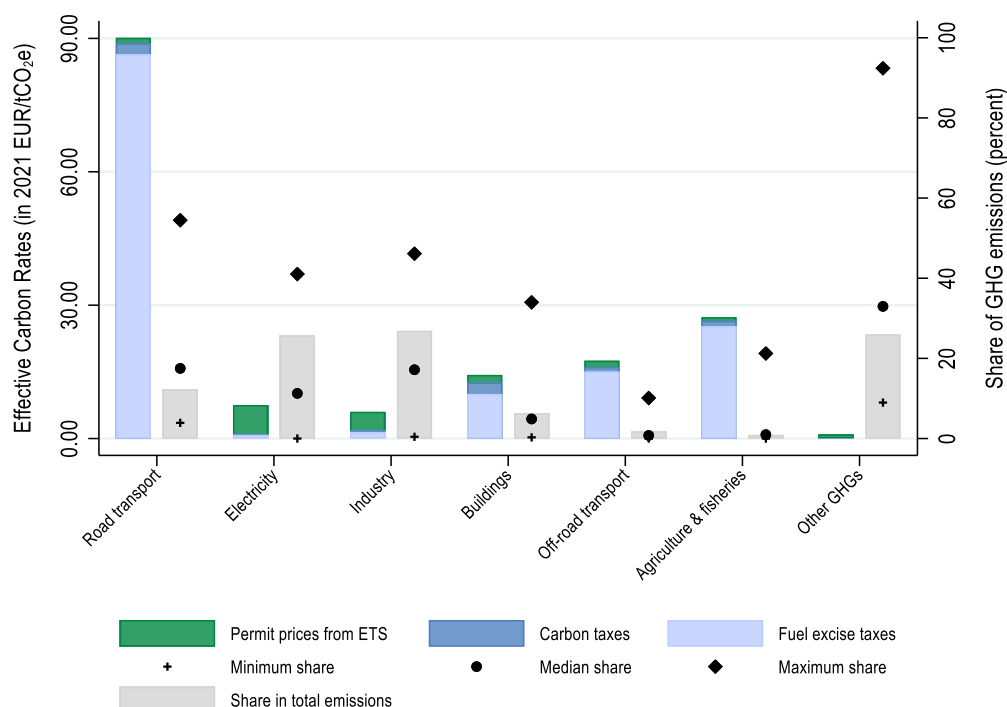
mostly through the pricing of industrial process emissions. Average carbon tax rates are highest in the road transport and buildings sectors, at about EUR 2.5 per tonne of CO₂ in both sectors. Carbon taxes cover about 0.14% of emissions from other GHGs; they make up a low share of the base and hence present an average close to 0, but range from EUR 0.46 to about EUR 59 per tonne of CO₂.

The most emitting sectors are not necessarily those that face the highest prices on average (Figure 2.3). Indeed, the industry and electricity sectors as well as other GHGs (emissions from CH₄, N₂O, F-gases and process CO₂ emissions) account for about one quarter each of emissions, but on average face lower ECRs than the agriculture and fisheries and off-road transport sectors which are responsible for much lower shares of total emissions (respectively almost 1% and 2%). Given political constraints facing carbon pricing and different abatement opportunities in different sectors, setting higher prices on larger emissions bases can be more challenging than for narrower emissions bases.

Sectoral shares can substantially vary across countries (Figure 2.3) and this variation influences average ECRs at the country level. Indeed, a low ECR can be due to a low carbon price or a narrow base. Sectoral shares widely vary: off-road transport sector emissions never make up more than 10.2% of a country's GHG emissions, while other GHG emissions can account for up to 92.4% of emissions in a country. This variation then influences country-level average ECRs. For example, a country with a higher share of other greenhouse gas emissions will tend to have a lower average ECR (since these emissions are hardly covered) than one with a higher share of emissions from the road transport sector (where ECRs are on the higher end of the distribution).

Figure 2.3. Carbon pricing instruments and share of GHG emissions by sector

2021, 72 countries



Note: The left-hand side bars of this graph show ECR components by sector. Together, emissions from the road transport, electricity, industry, buildings, off-road transport and agriculture and fisheries sectors make up CO₂ emissions from energy use. Other GHG emissions cover CH₄, N₂O and F-gas emissions as well as CO₂ emissions from industrial process. The right-hand side axis presents shares of emissions from these sectors in total emissions, as well as their country-level variation. “Minimum share” (resp. “Maximum share”) indicates the minimum share this sector may represent in a country’s total GHG emissions. “Median share” is the median of such shares across countries. For instance, the median share in the road transport sector indicates that half of countries in the sample have a road transport sector that accounts for more than 17.5% of national GHG emissions. Other GHG emissions data are from CAIT (Climate Watch, 2022^[1]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[2]). The equivalent figure when accounting for CO₂ emissions from biofuel combustion is presented in Annex A.

StatLink  <https://stat.link/96rp7d>

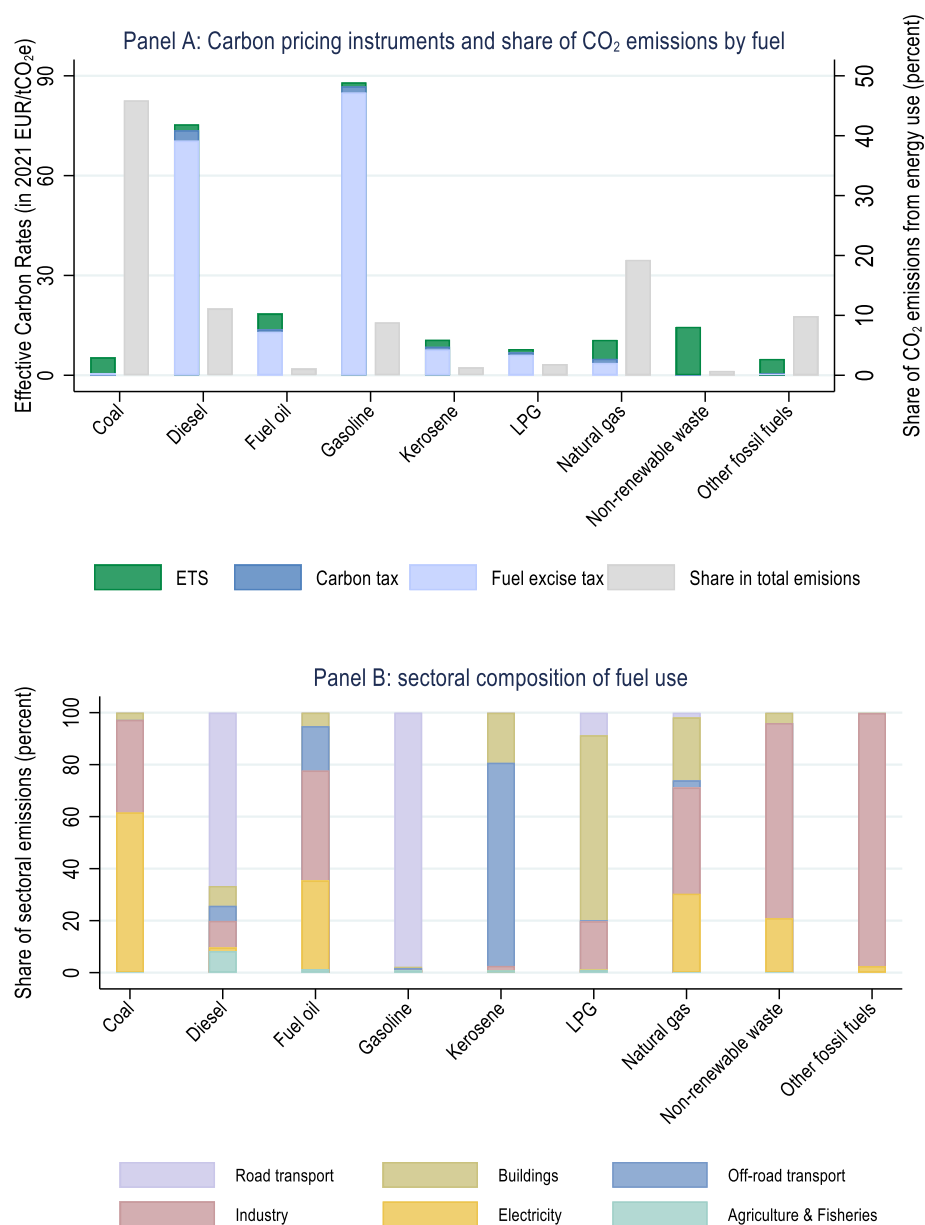
Fuel excise tax rates are relatively high for transport fuels (diesel and gasoline) and some heating fuels, and this translates into higher ECRs in the related sectors (Figure 2.4). On one end of the spectrum, diesel and gasoline, which are primarily used in the road transport sector, are subject to the highest fuel excise tax rates (translating to respectively EUR 70 and EUR 85 per tonne of CO₂ on average), which also relates to their historically broad tax base used by countries to raise revenue. On the other end of the spectrum, coal and other solid fossil fuels, which are mostly used in the industry and electricity sectors face relatively low effective carbon tax rates (at an average of EUR 5.4 per tonne of CO₂). Fuels such as LPG and natural gas, which are used in the buildings sector, stand in the middle, with average ECRs at about EUR 8/tCO₂ and EUR 10.6/tCO₂ respectively. These fuels often face reduced tax rates or exemptions, particularly when applying in the residential sector.

Country-level ECRs presented in Annex 2.A show that countries with the highest ECR levels and shares of emissions priced generally have emissions trading systems (see Annex Figure 2.A.2 and Annex Figure 2.A.3). This is consistent with the industry and electricity sectors presenting large shares of emissions and

mostly being priced by ETSs. The highest carbon tax rates can be found in countries with the highest ECRs. Fuel excise taxes still cover most priced emissions in most countries. Country-level average ECRs also depend on sectoral composition: countries with a high share of road transport sector emissions tend to have higher average ECRs (consistent with Figure 2.3).

Figure 2.4. ECR levels by fuel and sectoral composition of fuel emissions

2021, 72 countries



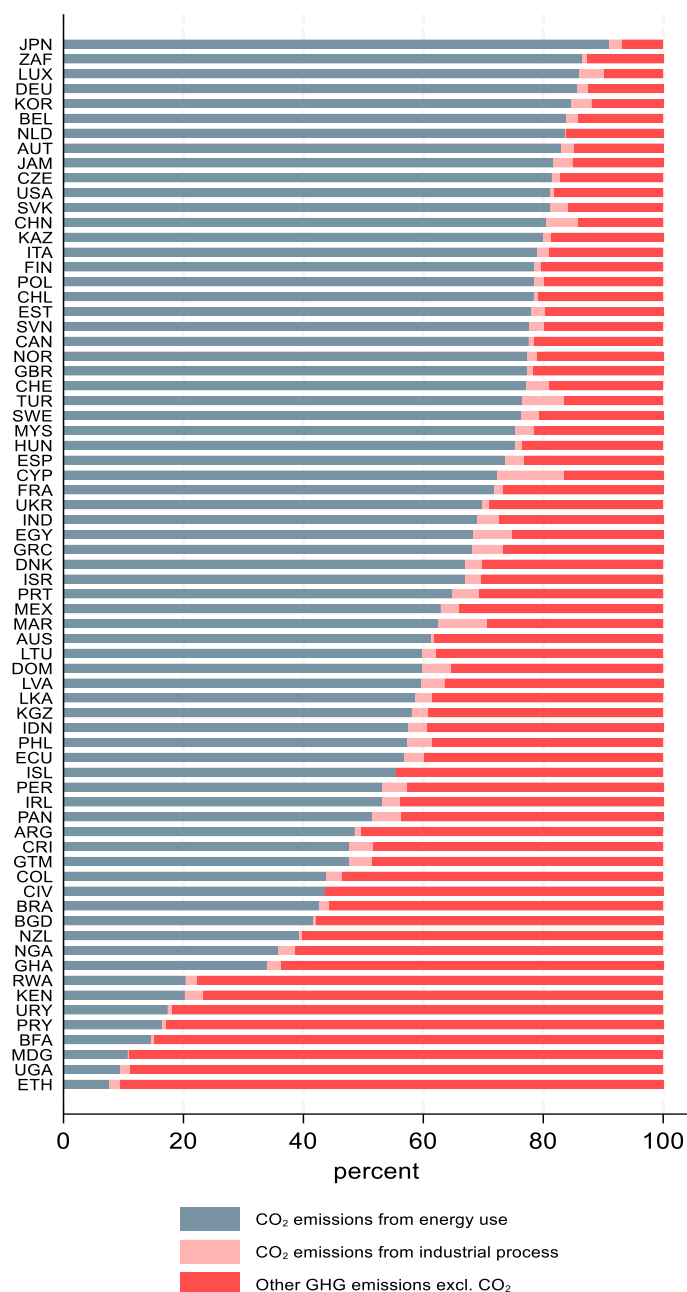
Note: "Coal" stands for "Coal and other solid fossil fuels". Other greenhouse gases are not included here as they are not fuel-based. CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023_[2]). The equivalent figure when accounting for CO₂ emissions from biofuel combustion is presented in Annex A.

StatLink  <https://stat.link/ikfjo2>

2.2. Other greenhouse gas emissions

Across all countries in the sample, CO₂ emissions from energy use represent a little less than three quarters of greenhouse gas emissions (74%), even though this share varies widely across countries. This depends in part on the importance of the agriculture sector in the economy (Figure 2.6). CO₂ emissions from energy use range from about 8% (Ethiopia) to 92% of total GHG emissions (Japan) (Figure 2.5).

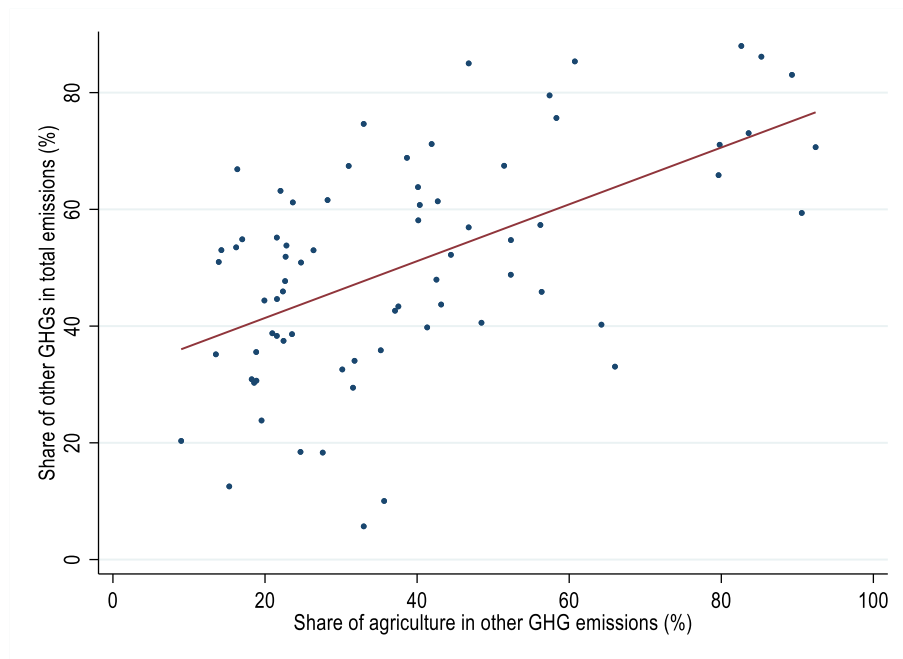
Figure 2.5. Share of CO₂ emissions from energy use in total GHG emissions



Note: Other GHG emissions stand for emissions from CH₄, N₂O, F-gases and process CO₂ emissions. In this figure, this category is split between CO₂ and non-CO₂ emissions. The other GHG emissions data (CAIT (Climate Watch, 2022^[1])) is for 2018, while the data on CO₂ emissions from energy use (based on the IEA World Energy Balances (IEA, 2023^[2])) is for 2021 for OECD and G20 countries as well as Cyprus and Kazakhstan, and 2018 otherwise.

StatLink  <https://stat.link/z6msxa>

Figure 2.6. Share of other GHGs emissions in total emissions and importance of agricultural emissions in a country



Note: Other GHG emissions stand for emissions from CH₄, N₂O, F-gases and process CO₂ emissions.

Source: CAIT (Climate Watch, 2022^[11]).

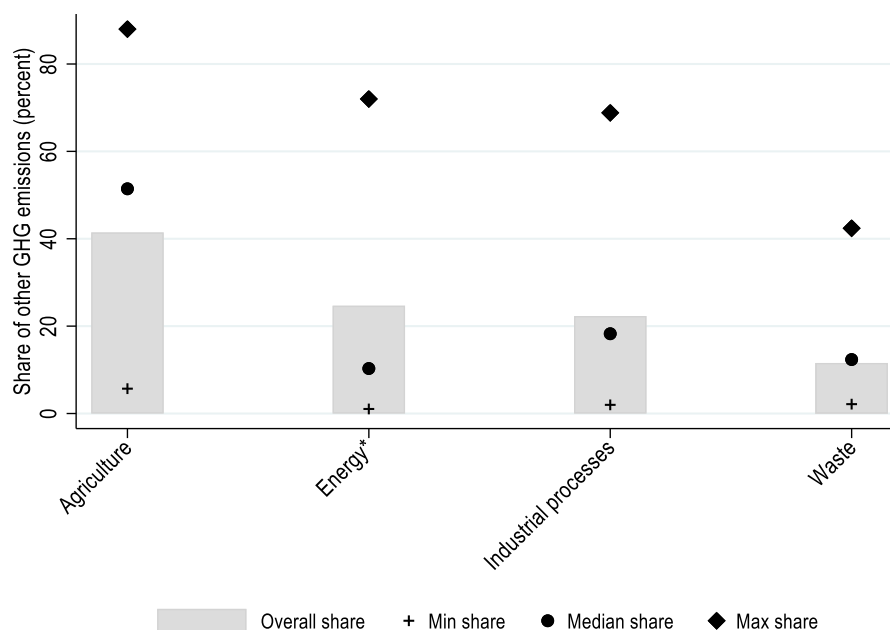
StatLink  <https://stat.link/fx6mby>

While uncertainties around the estimation of other GHG emissions levels (and the tax base corresponding to pricing instruments) are much higher than on levels of CO₂ emissions from energy use, available information on the GHGs and sectors that make up this category provides some insights into the strategies that may be used to price this non-negligible source of GHG emissions, which in 2021 remained largely unpriced (Figure 2.3). This may also help assess whether these emissions are tackled through other measures (Errendal, Ellis and Jeudy-Hugo, 2023^[3]). Uncertainties relating to methane (CH₄) emissions measurement are large for emissions from fugitive sources, landfills and wastewater. Nitrous oxide (N₂O) emissions from agricultural sources and F-gases emissions are also difficult to estimate accurately; the uncertainty range associated with these estimates can be set at a factor of two.³

Agricultural emissions account for the largest share of estimated other GHG emissions, both for the combined total of countries studied but also in most of these countries (Figure 2.7). More than half of the countries in the sample have more than 51.4% of their other GHG emissions stemming from non-energy related agricultural emissions. This share varies widely, ranging from 5.7% (in Israel) to about 88% (in Uruguay). Industrial processes as well as energy (fuel combustion resulting in non-CO₂ emissions and fugitive emissions) make up similar shares of estimated total other GHG emissions, at about 22% and 25% respectively. These shares can range from close to 1% (1.04% for energy in Uruguay and 1.98% for industrial processes in Uganda) to about 72% for energy (Russia) and 69% for industrial processes (Korea). Waste makes up a smaller share of other GHG emissions globally, and in most countries.

Figure 2.7. Sectoral composition of other GHG emissions

2018, 72 countries. Overall share of each sector in total other GHG emissions, minimum, median and maximum.



Note: *The “Energy” category here covers non-CO₂ related emissions from fuel combustion as well as fugitive emissions.

The overall share represents the share of each sector in total other GHGs (excluding LUCF). “Min share” (resp. “Max share”) represents the lowest country-level share of each sector in other GHGs (excluding LUCF) in the sample of 72 countries. “Median share” represents the value such that 50% of countries have a share above (or below) this value for that sector. For instance, “Median share” for the waste sector can be interpreted as follows: at the country level, the waste sector represents less than 12.35% of other GHG emissions (excluding LUCF) in 50% of the 72 countries.

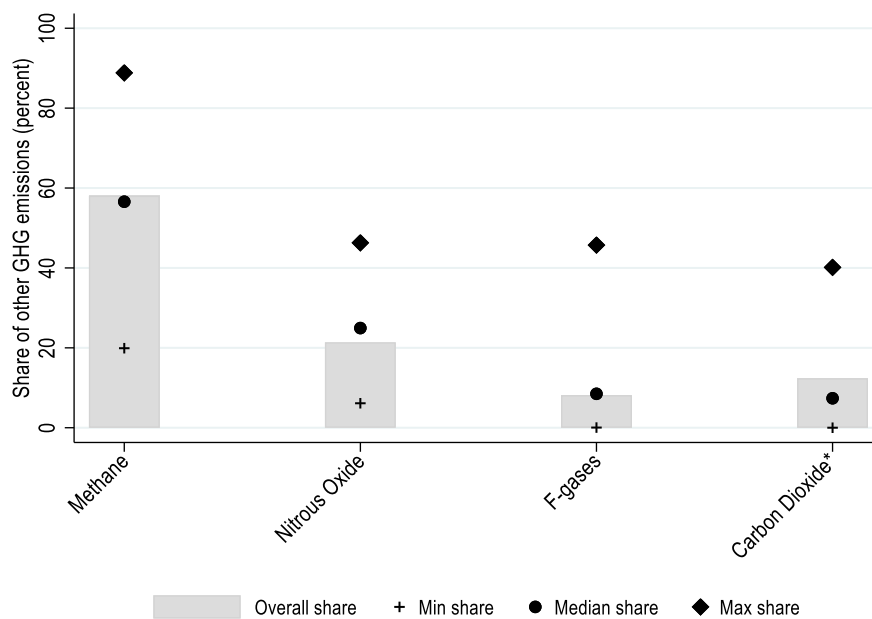
Source: CAIT (Climate Watch, 2022^[1]).

StatLink  <https://stat.link/dxri03>

Consistent with the sectoral decomposition of other GHG emissions, methane, which principally occurs in the agricultural sector, makes up the largest share of other GHG emissions (Figure 2.8). Energy, however, is steadily increasing to become a close second for methane emissions.⁴ While half the countries in the sample have an estimated share of F-gas emissions in other GHG emissions between 0.04% (Uganda) and 8.5% (Canada), this share can reach up to 45.7% (Korea), similar to the maximum share observed for N₂O (46.3% in Estonia). No country share of CH₄ emissions in other GHG emissions is below 19.9%.

Figure 2.8. GHGs responsible for other GHG emissions

2018, 72 countries. Overall share of each gas in total other GHG emissions, minimum, median and maximum.



Note: *CO₂ emissions here are from industrial process.

The overall share represents the share of each gas in total other GHGs (excluding LUCF). “Min share” (resp. “Max share”) represents the lowest country-level share of each gas in other GHGs (excluding LUCF) in the sample of 72 countries. “Median share” represents the value such that 50% of countries have a share above (or below) this value for that gas. For instance, “Median share” for N₂O can be interpreted as follows: at the country level, N₂O represents more than 25% of other GHG emissions (excluding LUCF) in 50% of the 72 countries.

Source: CAIT (Climate Watch, 2022_[1]).

StatLink  <https://stat.link/cmg3p5>

References

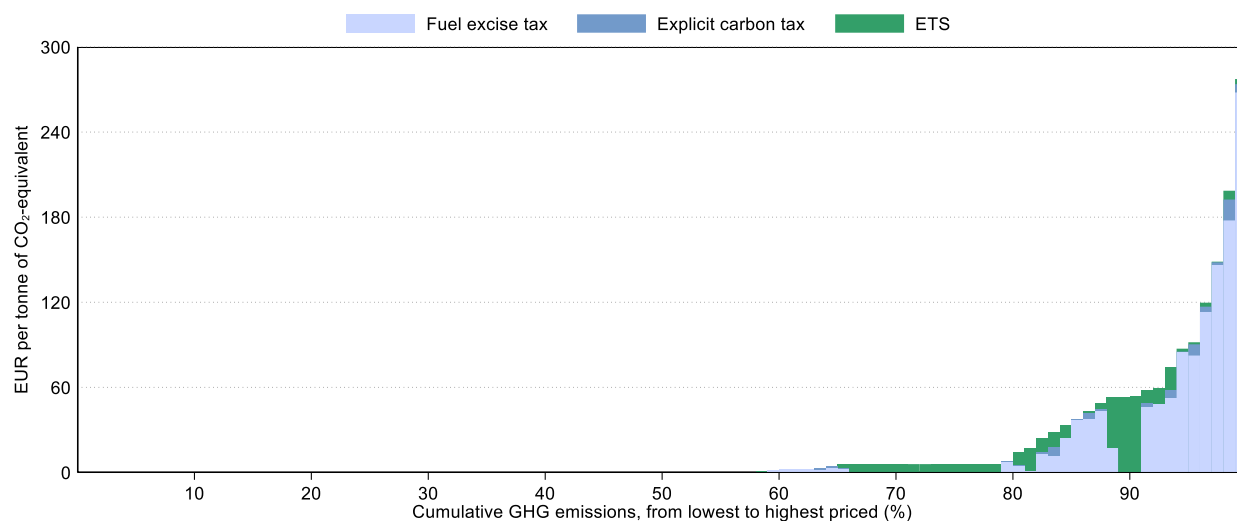
- Climate Watch (2022), <https://www.climatewatchdata.org>. [1]
- Errendal, S., J. Ellis and S. Jeudy-Hugo (2023), “The role of carbon pricing in transforming pathways to reach net zero emissions: Insights from current experiences and potential application to food systems”, *OECD Environment Working Papers*, No. 220, OECD Publishing, Paris, <https://doi.org/10.1787/5cefd8c-en>. [3]
- IEA (2023), “Extended world energy balances”, *IEA World Energy Statistics and Balances* (database), <https://doi.org/10.1787/data-00513-en> (accessed on 28 March 2023). [2]

Annex 2.A. Breakdown of Effective Carbon Rates by instrument and country

Breakdown of the distribution of ECRs by instrument

Annex Figure 2.A.1 Distribution of instrument-level ECRs across GHG emissions

2021, ECRs are broken down by instrument for each percentile



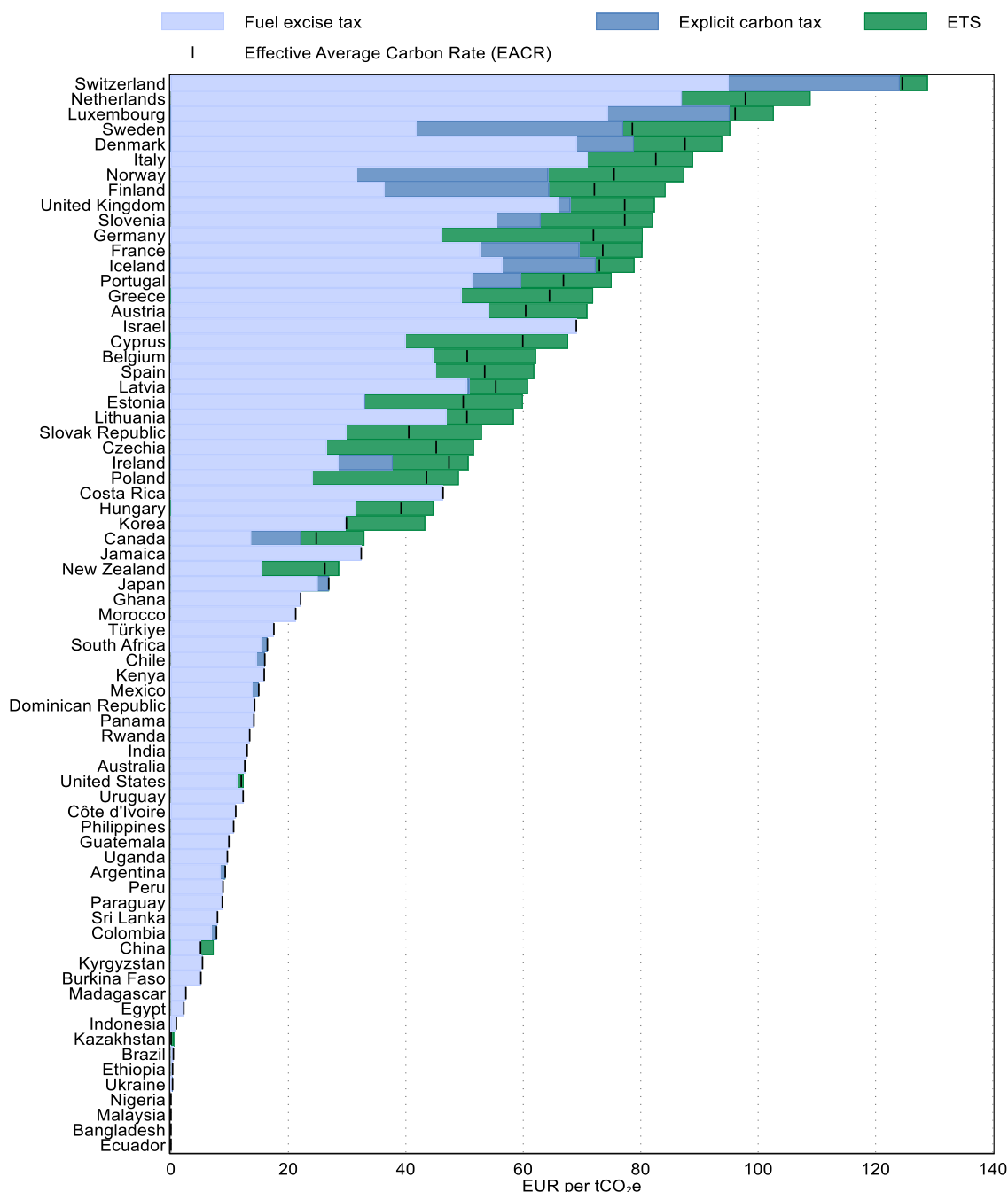
Note: For each percentile bracket, average rates are presented. Other GHG emissions data are from CAIT (Climate Watch, 2022^[1]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[2]).

StatLink  <https://stat.link/wdczoi>

Effective Carbon Rates levels and coverage by country

Annex Figure 2.A.2. Average Effective (Marginal & Average) Carbon Rates by country

2021, 71 countries

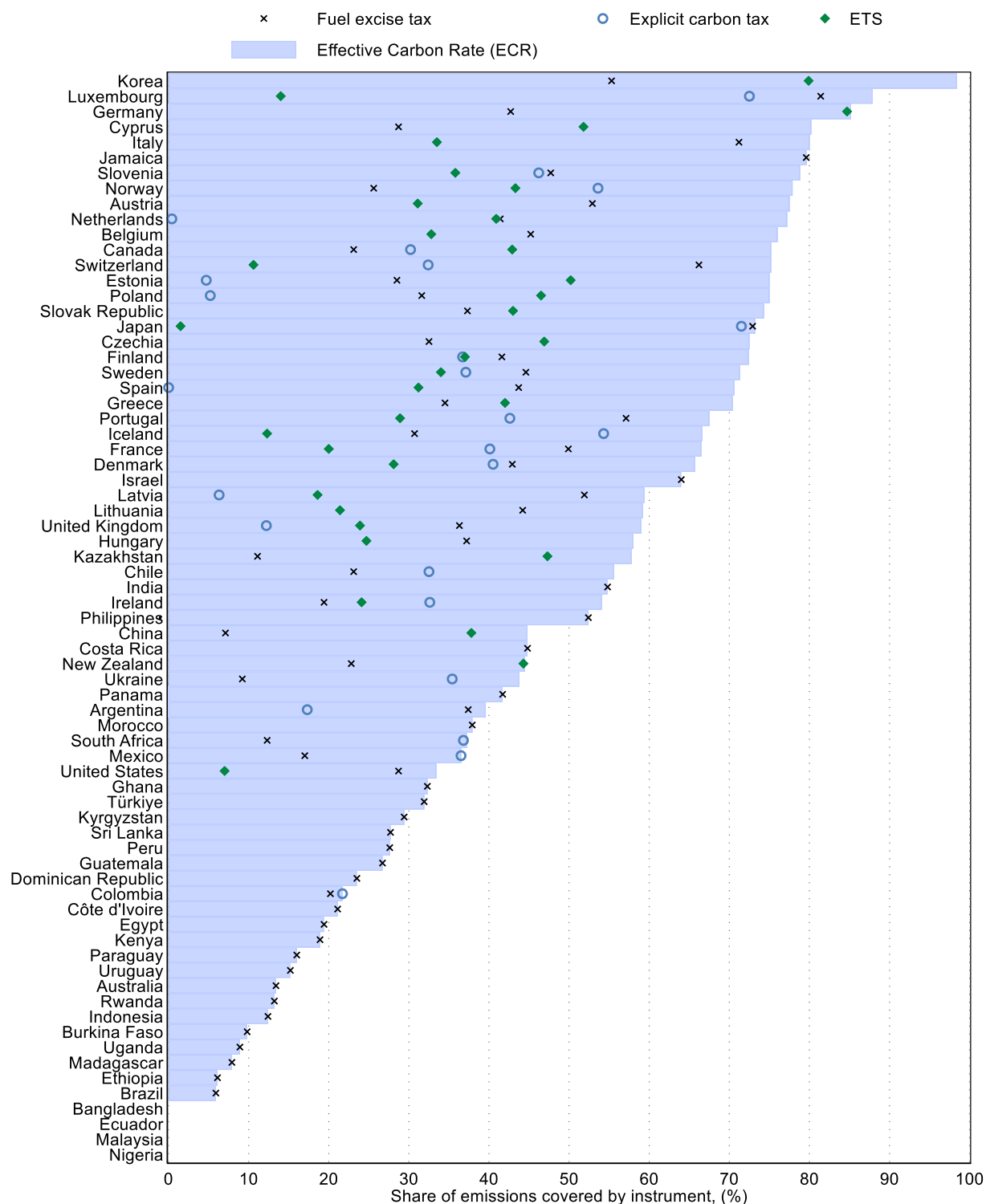


Note: Effective carbon rates are averaged across all GHG emissions, excl. LUCF, including those emissions that are not covered by any carbon pricing instrument, for each of the 71 countries. Effective Average Carbon Rates account for free allocation of allowances in emissions trading systems (see section 3.4). All rates are expressed in 2021 EUR using the latest available OECD exchange rate and inflation data. Prices are rounded to the nearest eurocent. Other GHG emissions data are from CAIT (Climate Watch, 2022^[1]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[2]).

StatLink  <https://stat.link/2s67g0>

Annex Figure 2.A.3. Country-level share of GHG emissions priced by ECR component

2021, 71 countries. Shares are presented in percent.



Note: Shares covered by ECRs are often less than sum of the shares covered by its components due to overlapping instruments. Percentages are rounded to the first decimal place. Other GHG emissions data are from CAIT (Climate Watch, 2022^[1]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[2]).

StatLink  <https://stat.link/8m6n53>

Notes

¹ While the former externality would not be present if a full switch to electric vehicles (EVs) took place, the other three externalities would remain.

² This latter point applies to the first six sectors which together are responsible for CO₂ emissions from energy use.

³ The IEA (2021^[4]) documentation on GHG emissions provides additional information on these uncertainties and advises that “figures provided for individual countries should be considered solely as order-of-magnitude estimates”.

⁴ At the global level, emissions from methane in agriculture went from about 3.2 Gt in 1990 to about 3.5 Gt today, while in energy, they went from about 2.3 Gt in 1990 to 3.4 Gt today (see historical trends from Climate Watch (2022^[1])). Moreover, the IEA’s Global Methane Tracker (IEA, 2022^[5]) finds that methane emissions from the energy sector are 70% higher than official figures, thus reinforcing this observation.

3 Emissions trading systems

Explicit carbon pricing instruments (i.e. emissions trading and carbon taxes) are increasingly being used to price emissions, and in recent years, emissions trading systems (ETSs) have gained importance both in terms of emissions coverage and of carbon price levels. Among the 72 countries considered in this report, ETSs have gone from covering about 13% of carbon dioxide (CO₂) emissions from energy use in 2018 to 27% in 2021. This is in large part due to the introduction of new ETSs in Canada, China and Germany within that time span. Since 2021, four new ETSs have been introduced, in Austria and Oregon in 2022 and in Mexico and Washington in 2023 (see section 3.3).¹ Several other countries or regions across the world are developing new ones (ICAP, 2023^[1]). New carbon taxes were introduced in Canada, Luxembourg, the Netherlands and South Africa between 2018 and 2021, but they hardly increased emissions coverage. Permit prices have also risen to levels above those of carbon tax rates. Indeed, permit prices rose in almost all ETSs between 2018 and 2021 and on average they almost increased by half over the period. While the average permit price was almost the same as the average carbon tax rate in 2018, the gap between ETS prices and carbon taxes has widened as carbon tax rates did not follow the same evolution over the following years (see Table 3.1).

Table 3.1. Evolution of coverage and rates of explicit carbon pricing instruments between 2018 and 2021

72 countries, for CO₂ emissions from energy use

Instrument	Coverage		Marginal explicit carbon rate (in constant 2021 EUR/tCO ₂)	
	2018	2021	2018	2021
Carbon tax	6.7%	6.9%	11.6	12.4
ETS	13%	27%	11.2	15.5

Note: The marginal explicit carbon rates presented in this table are the emissions-weighted averages of marginal carbon rates on emissions priced by the instrument considered. Prices and tax rates were converted into (constant) 2021 EUR using the latest available OECD exchange rate and inflation data.

3.1. Carbon taxation versus emissions trading systems

The relative merits of carbon taxation and emissions trading systems have been considered both theoretically and from a policy perspective. Weitzman (1974^[2]) established that both prices and quotas could lead to the same desired outcome, but not when there is uncertainty about compliance costs. In that case, depending on the shapes of the marginal abatement cost curve and of the marginal damage curve of carbon emissions, one instrument may be more effective than the other. This result has been widely discussed over the years, and hybrid regimes, that would combine both carbon pricing instruments² have been shown to provide more benefits (see (Roberts and Spence, 1976^[3]), (Nordhaus, 1994^[4]) (Pizer, 1997^[5]) (Flues and van Dender, 2020^[6])). Several factors may influence the preference for one instrument over the other (see, e.g. Black et al. (2022^[7])), including administrative capacity, political feasibility, preference for price or quantity certainty.

3.1.1. Price versus quantity certainty

Carbon taxes may provide more price certainty than ETSs. Depending on how they are set, this can ensure certainty on carbon prices both today and in the future. However, taxes are also the result of political decisions and processes; rates may be frozen, or taxes cancelled (for instance, Slovenia cancelled its carbon tax in 2023, see Chapter 4). Moreover, uncertainty about abatement costs can make it hard to set the right tax rate – i.e. at a level that encourages cutting a desired quantity of emissions.

ETSs provide certainty on quantity of emissions but permit prices can be volatile. In most ETSs that do not have a fixed price, caps are pre-announced together with their future trajectory. For example, the European Union emissions trading system (EU ETS) has a total cap of 1 572 MtCO₂e in 2021 (the first year of its fourth phase), subject to a linear reduction factor of 2.2% per year with no sunset clause (ICAP, 2022^[8]).

Price stability mechanisms (further discussed in section 3.5) can help deal with price uncertainty. Providing stability mechanisms for carbon price levels and paths is important to help firms adapt and plan, as well for investors to be able to make long-term decisions. Price stability mechanisms include carbon price floors such as that which was introduced in the industry sector in the Netherlands in 2021 (OECD, 2021^[9]) or which is currently being discussed in Denmark (Skatteministeriet, 2022^[10]). They can also operate through market stability reserves, such as in the EU ETS (see section 3.5). Moreover, while it does not ensure price stability, auctioning is used in some systems such as the Chinese pilots of Fujian and Hubei for price discovery. Indeed, auctioning, by revealing a carbon price based on covered installations' demand, can allow an alignment of carbon prices with abatement costs.

3.1.2. Administrative considerations

The administrative burden is generally lower for carbon taxes than for ETSs, as carbon taxes can easily build off existing fuel excise taxes for design and collection. ETSs, however, require more sophisticated monitoring, reporting and verification (MRV) systems. Their complexity also depends on whether they are applied upstream or downstream.³ These differences can help explain why in countries with less sophisticated administrative systems, explicit carbon pricing is administered through carbon taxation. Taxing *non-energy* related emissions does require emissions measurement systems (since such emissions do not depend on fuel use), which may also explain why most covered process emissions are priced through an ETS, where the MRV system is already in place.

Administrative considerations also include the ministry responsible for collecting revenue from different instruments. Carbon taxes generally fall within the purview of a country's Ministry of Finance, whereas ETSs are generally linked to Ministries of Environment, with the former having more experience with revenue collection.

3.1.3. Revenue raising properties and use

Both instruments have the potential to generate revenue; however, ETSs that exclusively rely on the free allocation of allowances with no auctions do not raise revenue and forgo revenue. Marten and Van Dender (2019^[11]) characterise the revenue raising properties of these instruments in more detail. Excise tax revenues are commonly used in general budgets, carbon tax revenues are more often used in the context of a tax reform and ETS revenues are more likely to be earmarked for environmental purposes (Parry, Black and Zhunussova, 2022^[7]; Marten and van Dender, 2019^[11]). The use of revenues raised from the auctioning (or sale) of ETS permits can range from no earmarking (e.g. in Switzerland, the United Kingdom and most Chinese pilots) to partial (e.g. the EU ETS) or total earmarking (e.g. in Quebec, Germany or Korea). The difference in revenue use between the carbon taxes and ETSs can also be due to the conceptual difference between these instruments, in the sense that tax revenue has historically been assigned to countries' general budget and that allocating it to a specific purpose requires modifying their tax system through legislative changes.

While earmarking the revenue raised from one type of tax does not necessarily guarantee the most efficient use of funds, it can contribute to political acceptance especially in the case of explicit carbon prices. Surveys or experiments show that revenue recycling has a positive effect on the political acceptability of environmental taxation (Douenne and Fabre, 2020^[12]; Beiser-McGrath and Bernauer, 2019^[13]; Kallbekken, Kroll and Cherry, 2011^[14]). However, from an economic point of view, the fiscal budget should be considered in its integrity and assigned to different spending areas (e.g. environmental transition, but also health, education, security, etc.) in a way that is optimal to society. From a pure democratic principle point of view as well, some countries, such as France adhere to universality principles,⁴ which should guarantee that a particular tax revenue is not reserved for a particular expenditure type. This principle is in part meant to guarantee that the democratic process does not lose too much ground with respect to the administrative process. In practice, the numerous exceptions to these principles which exist for other taxes and the political feasibility argument may constitute good enough reasons to recycle revenue from carbon taxes.

3.1.4. Constitutional and legal considerations

ETs are sometimes chosen over carbon taxes for constitutional or legal reasons (Parry, Black and Zhunussova, 2022^[7]). For example, in the EU, voting on tax matters requires unanimity whereas regulations like an ETS require a qualified majority, so that passing the political process of an EU-wide carbon tax might have been harder. Similarly for California, passing an ETS required approval from half of the legislature as compared to two-thirds for a carbon tax.

3.1.5. Free allocation and average vs. marginal rates

While revenue recycling can foster political support, the provision of free allowances in ETs can also help garner support for their introduction as they address competitiveness and carbon leakage concerns. However, this approach can mute the average carbon price signal provided by ETs and discourage low-carbon investment (see section 3.4 and (Flues and Van Dender, 2017^[15])). A noteworthy exception is the Regional Greenhouse Gas Initiative (RGGI), the United States' first ETS, which was introduced in 2009 in Connecticut, Delaware, Maine, Massachusetts, Maryland, New Hampshire, New Jersey, New York, Rhode Island and Vermont. The RGGI managed to gain support with little or no free allocation shares. The political feasibility of such a policy can be explained by several factors, including the earlier experience of the EU ETS carbon market crash in 2006, which was attributed to the over-allocation of free permits, as well as the concerns over windfall profits in the power sector (see section 3.4). Another explanation revolves around the prior restructuring of the electricity market in many concerned states, which reduced the control an individual state had over the electricity rates paid by their residents, thereby influencing the alignment between states once a state decided to auction a higher share of allowances. This restructuring also created diverging incentives among energy utilities (Huber, 2013^[16]).

Most carbon taxes are applied uniformly on a base, so they have the same marginal and average rates. Hence, except when they exempt part of the emissions base (as is the case in South Africa for example), their average price signal is unmuted. This maintains incentives for investment in clean technologies. This is not the case for ETs where they provide free allocation of allowances, creating a gap between the marginal and the average price signals. Indeed, regardless of whether a firm's emissions are covered by free permits, the incentive to abate an additional tonne of CO₂ remains unaffected, as the firm can generate additional income by selling a permit on the market; the marginal price signal is maintained. However, if a firm's emissions are covered by free permits, then the firm does not need to buy a certain share of permits, so the total cost of its CO₂ emissions is lower, as is the average rate paid per tonne of CO₂ emitted. Free allowances then imply higher profits for carbon-intensive projects and thus risk changing project ranking to the detriment of clean technologies (Flues and van Dender, 2020^[6]).

Even though carbon taxes apply uniformly to a fuel base, they do not apply uniformly in sectors as they often only cover a subset of fuels. For instance, natural gas is not covered by the carbon tax in Argentina,

so that about 77% (resp. 63%) of emissions in its electricity (resp. industry) sector face no carbon tax. Moreover, since carbon taxes are generally based on the CO₂ content of fuels, they rarely apply to non-fuel-based GHG emissions (except in Denmark, Iceland, the Netherlands, Norway, Poland and Spain).

3.1.6. Additional considerations

Lastly, when applied downstream, ETSs can mitigate carbon leakage in the aviation sector.⁵ While kerosene taxation provides broader coverage and greater certainty (Teusch and Ribansky, 2021^[17]), it also requires international alignment, which carries the risk of significant carbon leakage. Indeed, in the context of international aviation, kerosene constitutes a highly mobile tax base, since if its taxation is higher in one jurisdiction than in another, the aircraft operator may recharge in the jurisdiction where the tax rate is lower.

Downstream ETS coverage can effectively address the issue of tax-base shifting, although competitiveness concerns may persist. These latter concerns can help explain the high share of free allocation in this sector: most countries with an ETS which covers aviation provide more than 50% of free allocation of allowances to the sector, and often overshoot verified emissions. New Zealand stands out as an exception, as it does not provide free allocation of allowances for aviation, and this is covered upstream by the national ETS. In December 2022, the European Parliament and the Council of the EU reached a provisional agreement on reforming the EU ETS as part of the negotiating process to deliver on the European Green Deal. This agreement included the gradual phase-out of free allocation for aviation by 2026 (ICAP, 2023^[11]).⁶

In practice, the choice between a tax or an ETS is not clear-cut, and in several jurisdictions, both co-exist, sometimes on the same emissions base (either in a coordinated or uncoordinated way). The United Kingdom, for example, introduced the carbon price support in 2013, which initially complemented pricing by the EU ETS and now the UK ETS for the power sector (see section 3.5). Sweden has had a carbon tax covering its road transport emissions since 1991 and its emissions from the electricity and industry sectors are covered by the EU ETS. In Canada, since 2019, several provinces and territories have introduced carbon taxes and ETSs for compliance with sets minimum national stringency standards (the federal 'benchmark') that all systems must meet and that provide flexibility to the provinces and territories to choose either their own systems or the federal pricing one. This has resulted in emissions in all thirteen Canadian provinces and territories being covered by an ETS, a carbon tax or both in 2021, as opposed to only two provinces having a carbon tax and three an ETS in 2018. It has also led to a change in emissions coverage by instrument, with carbon tax coverage almost doubling (from 22% to 39% of CO₂ emissions from energy use) and ETS coverage stagnating at 48% of CO₂ emissions from energy use.

In some cases, the design of both instruments may be similar. The German and Austrian national ETSs present similar characteristics to a carbon tax as they are levied upstream (on fuel suppliers) and until 2025, have a fixed price. When carbon taxes exempt emissions below a certain threshold, this can be equivalent to free allocations.

3.2. Emission trading systems in 2021

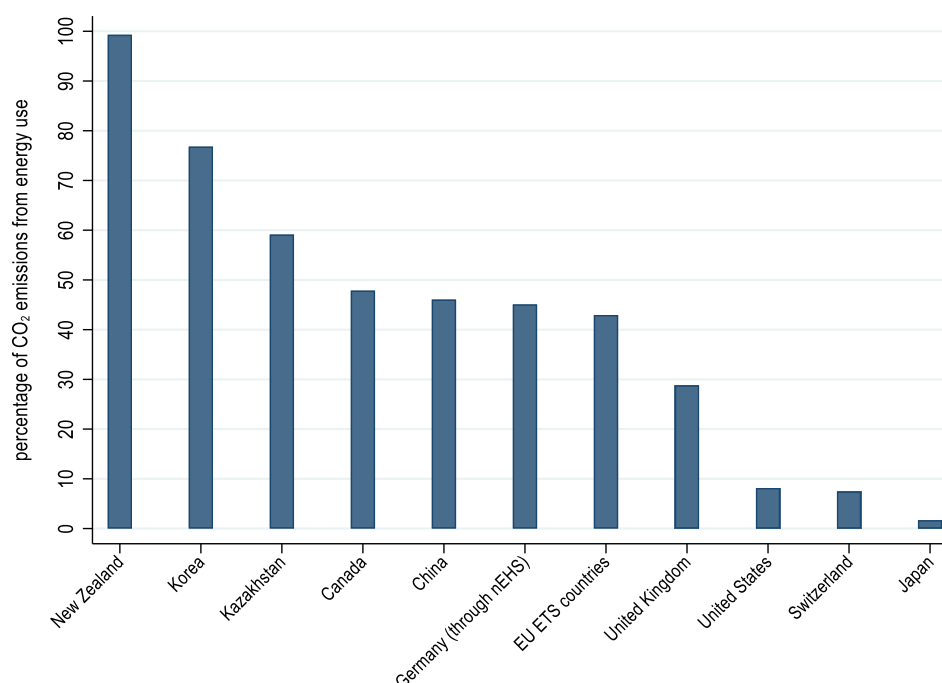
In 2021, in the sample of 72 countries considered in this report, there were 33 ETSs, covering 35 of these countries. The ETSs were at city, province or state, country or even supranational level. Thirty-four countries⁷ of this edition's sample had an ETS with positive permit prices⁸ in 2021. Their emissions account for 66% of the sample's GHG emissions.

As compared to 2018, ETS coverage of CO₂ emissions substantially increased in 2021, in China and in Germany. In these two countries, the shares of ETS coverage of CO₂ emissions from energy use went up respectively from about 10% to 46% and from about 53% to 95%. In China, this is due to the introduction of the Chinese national ETS for its power sector (covering both main electricity generation plants and

captive power plants). In Germany, the increase stemmed from the introduction of the German national ETS on transport and heating fuel distributors. In Canada, the introduction of the federal carbon pollution pricing backstop system in 2019 brought about the introduction of the federal Output-Based Pricing System (federal OBPS or FOBS) or provincial OBPSs in eight provinces or territories. This resulted in more provinces and territories being covered by an ETS in 2021 but resulting country-level ETS coverage remained the same as in 2018. In 2021, following Brexit agreements, the UK national ETS was launched, where the ETS coverage hardly changed, going from 32% to 29% of CO₂ emissions from energy use. In 2021, the share of CO₂ emissions from energy use covered by ETSs in different countries varies substantially, ranging from about 1.7% in Japan to 99.3% in New Zealand (Figure 3.1).

Figure 3.1. Shares of CO₂ emissions from energy use priced by ETSs

In countries or supranational jurisdictions that have an ETS with positive permit prices, 2021



Note: The share presented for Germany separately from the rest of EU ETS countries refers to the share of CO₂ emissions from energy use covered by its national ETS (nationaler Emissionshandelssystem, or nEHS). The share presented for EU ETS countries is the total share over all EU ETS countries covered in this report. The EU ETS applies to all EU countries as well as Iceland, Liechtenstein and Norway. The ECR database in this report does not cover Bulgaria, Croatia, Liechtenstein, Malta and Romania. Mexico's pilot ETS is not presented here because prices were null in 2021. Canada, China, Japan and the United States each have sub-national ETSs, and the country-level share of emissions covered by these systems (along with the national ETS for China) are presented here. The equivalent figure when accounting for CO₂ emissions from biofuel combustion is presented in Annex A. .

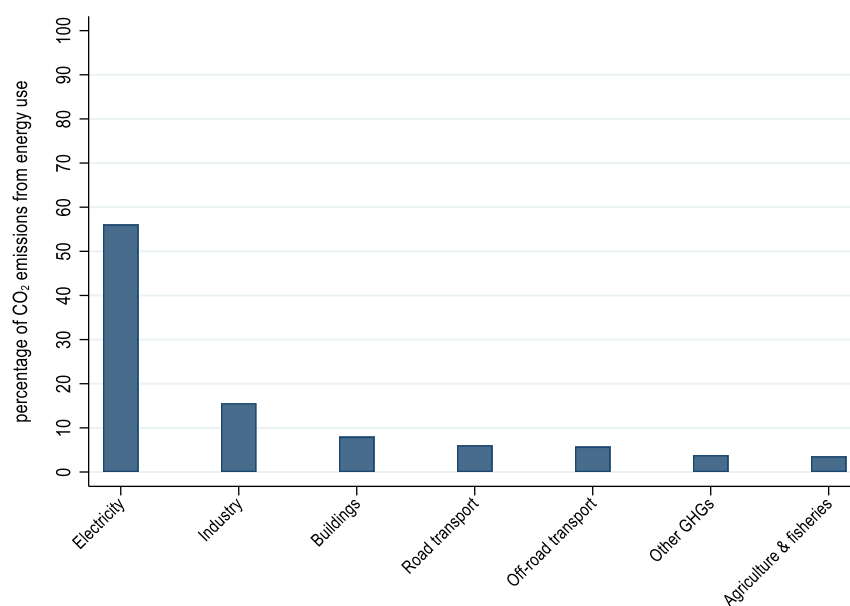
StatLink  <https://stat.link/6xfjyw>

In 2021, ETSs mainly cover the electricity and industry sectors (Figure 3.2). About 56% of the 72 country-sample's electricity sector emissions are covered by an ETS. This stems in large part from the newly introduced Chinese national ETS, which covers China's power sector, and in a second instance from the EU ETS, which covers almost all of EU countries as well as Iceland's, Liechtenstein and Norway's power sector emissions. Indeed, the Chinese power sector accounts for about 46% of total emissions from the electricity sector and the EU ETS countries' for about 5%. The industry sector comes next, with about 16% of total emissions covered by an ETS. All ETSs cover a part of the industry sector (Table 3.2). Even ETSs

covering emissions from power plants only extend in part to the industry sector through their coverage of captive power plants (see ECR sector definitions in Table 2.1, with autogeneration of electricity included in the industry sector). Almost 8% of the buildings' sector emissions are covered by an ETS, and this mostly comes from the introduction of the German nEHS. Indeed, the German buildings sector makes up 4.7% of total buildings emissions. The most targeted off-road transport emissions are from aviation (72% of covered emissions from off-road transport) and pipeline transport (10%). Other GHG emissions covered are mostly from process emissions – even when ETSs cover only CO₂ emissions (see Table 3.2). The road transport sector is covered through upstream systems such as the California Cap and Trade, New Zealand's ETS and the German national ETS. In total, this results in 68.7% of emissions covered by ETSs relating to the electricity sector, 20% to the industry sector, 4.7% to other GHGs, 3.5% to the road transport sector, 2.4% to buildings and less than 1% to the off-road transport sector.

Figure 3.2. Share of sectoral total emissions covered by an ETS

By sector, 2021, 72 countries

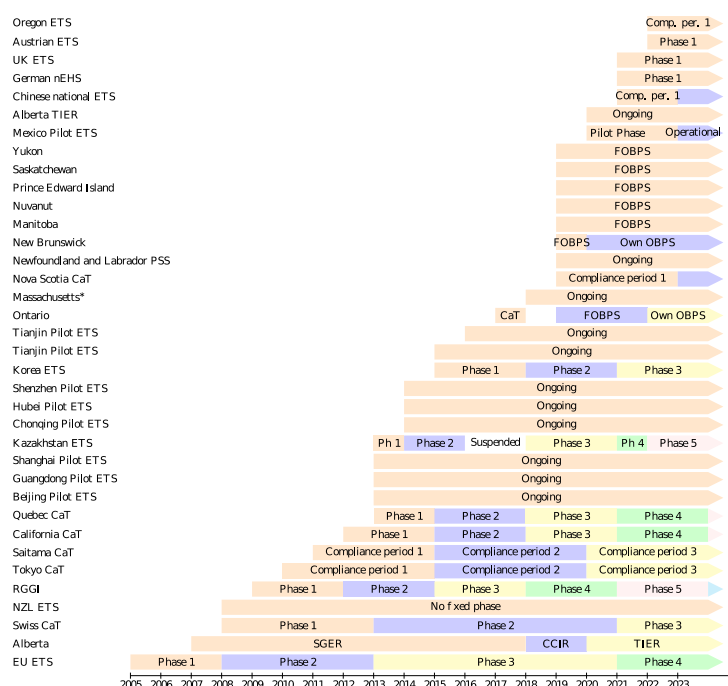


Note: The ETSs considered for the calculations presented in this figure are those present in Table 3.2 (33 ETSs). The equivalent figure when accounting for CO₂ emissions from biofuel combustion is presented in Annex A.

StatLink  <https://stat.link/gq48lt>

Between the last Effective Carbon Rates edition (OECD, 2021^[18]), which considered carbon pricing instruments in 2018 and this edition, which focuses on 2021, new ETSs were introduced, and many ETSs have also entered a new phase or compliance period (Figure 3.3). This has involved changes in caps (e.g. the EU ETS, RGGI, Kazakhstan ETS), increases in annual reduction factors or compliance factors (e.g. California Cap-and-Trade, Swiss ETS, EU ETS, Saitama and Tokyo Cap-and-Trade), changes in free allocation of allowance shares or calculations (e.g. the EU ETS, Korea ETS, Quebec Cap-and-Trade), changes in free allocation rules (Kazakhstan went from a mix of grandfathering and benchmarking to full benchmarking) or an expansion in scope (the Korean ETS started covering new sub-sectors such as freight, rail and shipping).

Figure 3.3. Emissions trading systems phases



Note: The Alberta TIER is its Technology Innovation Emissions Reduction regulation. OBPS stands for Output-Based Pricing System, FOBPS for Federal Output-Based Pricing System. The Newfoundland and Labrador PSS is its Performance Standards System. nEHS refers to "nationaler Emissionshandelssystem", which is German's national ETS. RGGI stands for Regional Greenhouse Gas Initiative.

Source: Authors' own elaboration based on (ICAP, 2023^[11]).

Some ETSs cover emissions domestic or regional aviation (Table 3.2). The EU ETS covers aircraft operators' flights within the European Economic Area (EEA), the Swiss ETS, flights within Switzerland as well as to the EEA and the UK and the UK ETS, flights within the UK and to the EEA.⁹ Half of Chinese pilots cover domestic aviation. While these systems apply downstream to aviation, the New Zealand ETS applies upstream, by covering kerosene suppliers.

Table 3.2. ETS characteristics across different jurisdictions in 2021

Emissions Trading Systems	Countries covered	Sectors covered ⁽¹⁾	Aviation covered	Greenhouse gases covered	Point of regulation	Free allocation method	Revenue use
Alberta TIER	Canada	Electricity, Industry	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , NF ₃ , HFCs, PFCs	Downstream	Grandparenting and Benchmarking	Partial or total earmarking
FOBPS	Canada (Manitoba, Nunavut, Ontario, Prince Edward Island, Yukon and Saskatchewan)	Electricity, Industry	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , NF ₃ , HFCs, PFCs	Downstream	Benchmarking	Partial or total earmarking
New Brunswick OBPS	Canada	Electricity, Industry	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , NF ₃ , HFCs, PFCs	Downstream	Grandparenting and Benchmarking	Partial or total earmarking
Newfoundland and Labrador PSS	Canada	Electricity, Industry	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , HFCs, PFCs	Downstream	Grandparenting and Benchmarking	Partial or total earmarking
Nova Scotia Cap-and-Trade	Canada	Agriculture and fisheries, Buildings Electricity, Industry (except CO ₂ emissions from cement production), Off-road transport, Road transport	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , NF ₃ , HFCs, PFCs	Upstream and Downstream	Grandparenting and Benchmarking	Partial or total earmarking
Quebec Cap-and-Trade	Canada	Agriculture and fisheries, Buildings Electricity, Industry, Off-road transport, Road transport	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , NF ₃ , HFCs, PFCs	Upstream and Downstream	Benchmarking	Partial or total earmarking

Saskatchewan OBPS	Canada	Industry (except natural gas transmission pipeline sector)	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , NF ₃ , HFCs, PFCs	Downstream	Grandparenting and Benchmarking	Partial or total earmarking
Chinese national ETS	China	Electricity, Industry (autogeneration of electricity)	No	CO ₂	Downstream	Benchmarking	n.a.
Beijing Pilot ETS	China	Buildings, Industry	No	CO ₂	Downstream	Grandparenting and Benchmarking	No earmarking
Chongqing Pilot ETS	China	Industry	No	CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆	Downstream	Grandparenting	No earmarking
Fujian Pilot ETS	China	Industry, Off-road transport	Yes	CO ₂	Downstream	Grandparenting and Benchmarking	No earmarking
Guangdong Pilot ETS	China	Industry, Off-road transport	Yes	CO ₂	Downstream	Grandparenting and Benchmarking	No earmarking (though earmarking has been considered)
Hubei Pilot ETS	China	Industry	No	CO ₂	Downstream	Grandparenting and Benchmarking	No earmarking
Shanghai Pilot ETS	China	Buildings, Industry, Off-road transport	Yes	CO ₂	Downstream	Grandparenting and Benchmarking	No earmarking
Shenzhen Pilot ETS	China	Industry	No	CO ₂	Downstream	Grandparenting and Benchmarking	No earmarking (though considered in the 2022 revision)
Tianjin Pilot ETS	China	Industry, Off-road transport	Yes	CO ₂	Downstream	Grandparenting and Benchmarking	Partial earmarking
EU ETS	EU countries and Iceland, Liechtenstein and Norway ⁽²⁾	Agriculture and fisheries, Buildings Electricity, Industry, Off-road transport	Yes	CO ₂ , N ₂ O, F-gases	Downstream	Benchmarking	Total or partial earmarking
German nEHS	Germany	Agriculture and fisheries, Buildings,	No	CO ₂	Upstream	n.a.	Total or partial earmarking

		Industry, Off-road transport, Road transport					
Saitama Cap-and-Trade	Japan	Buildings, Electricity, Industry	No	CO ₂ from energy use	Downstream	Grandparenting and Benchmarking	n.a.
Tokyo Cap-and-Trade	Japan	Buildings, Electricity, Industry	No	CO ₂ from energy use	Downstream	Grandparenting and Benchmarking	n.a.
Kazakhstan ETS	Kazakhstan	Electricity, Industry	No	CO ₂	Downstream	Benchmarking	n.a.
Korea ETS	Korea	Buildings, Electricity, Industry, Off-road transport, Road transport	Yes	CO ₂ , CH ₄ , N ₂ O, HFCs, PFCs, SF ₆	Downstream	Grandparenting and Benchmarking	Total or partial earmarking
Mexico Pilot ETS	Mexico	Electricity, Industry	No	CO ₂	Downstream	Grandparenting	n.a.
New Zealand ETS	New Zealand	Agriculture and fisheries, Buildings Electricity, Industry, Off-road transport, Road transport	Yes	CO ₂ , CH ₄ , N ₂ O, SF ₆ , HFCs, PFCs	Upstream and Downstream	Benchmarking	No earmarking (change in 2022)
Switzerland ETS	Switzerland	Electricity, Industry, Off-road transport	Yes	CO ₂ , NO ₂ , CH ₄ , HFCs, NF ₃ , SF ₆ , and PFCs	Downstream	Benchmarking	No earmarking
UK ETS	United Kingdom	Agriculture and fisheries, Buildings Electricity, Industry, Off-road transport	Yes		Downstream	Benchmarking	No earmarking
California Cap-and-Trade	United States	Agriculture and fisheries, Buildings Electricity, Industry, Off-	No	CO ₂ , CH ₄ , N ₂ O, SF ₆ , HFCs, PFCs, NF ₃ , and other fluorinated GHGs ⁽³⁾	Upstream and Downstream	Benchmarking	Total or partial earmarking

		road transport, Road transport					
Massachusetts Limits on Emissions from Electricity Generators (310 CMR 7.74)	United States	Electricity, Industry (autogeneration of electricity)	No	CO ₂	Downstream	n.a.	Total or partial earmarking programs
RGGI (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Rhode Island, Vermont and Virginia)	United States	Electricity, Industry (autogeneration of electricity)	No	CO ₂	Downstream	n.a.	Total or partial earmarking

Note: n.a. stands for not applicable. The Alberta TIER is its Technology Innovation Emissions Reduction regulation. OBPS stands for Output-Based Pricing System, FOBPS for Federal Output-Based Pricing System. The Newfoundland and Labrador PSS is its Performance Standards System. In Saskatchewan, the federal OBPS applies partially only to electricity generation and natural gas transmission pipelines. The provincial OBPS in Saskatchewan covers Industry except natural gas transmission pipelines. nEHS refers to "nationaler Emissionshandelssystem", which is German's national ETS. RGGI stands for Regional Greenhouse Gas Initiative. ⁽¹⁾ Country-level ECRs presented in Annex (see Table 1.1), restricting to the 6 sectors Agriculture and fisheries, Buildings, Electricity, Industry, Off-road transport and Road transport. ⁽²⁾ 25 of the 30 countries covered by the EU ETS are included in this ECR edition's sample of countries. ⁽³⁾ Compliance obligations are currently only assessed on CO₂, CH₄, and N₂O emissions. As a reminder, upstream regulation focuses on fuel suppliers whereas downstream regulation applies at the point where CO₂ or other GHGs are emitted (e.g. on industrial installations or power plants themselves). Hence, upstream regulation implies that distributors must acquire permits, whereas downstream regulation implies that operators must acquire permits.

Source: ICAP (2023^[19]), Environment and Climate Change Canada (2020^[20]), IETA (2022^[21]), IETA (2022^[22]).

3.3. Developments in Emissions Trading Systems since 2021¹⁰

Permit prices taken in current local currency units (LCUs) increased in all ETSs between 2021 and 2022 but decreased in certain systems between 2022 and early 2023 (especially in the Chongqing Pilot ETS, Korea and New Zealand where permit prices decreased by more than 15%). When accounting for inflation, permit prices also increased or hardly changed in all systems between 2021 and 2022, but decreased in more systems between 2022 and 2023. There are important variations in the price change levels and directions between systems, even within a country (Table 3.3). In most Canadian ETSs, the price path was set at the federal level,¹¹ and increased at a higher rate than inflation, implying a price increase over the whole period. In Quebec, where permit prices were determined by market forces (through auctions and secondary market transactions), the permit price has undergone a slight decrease in early 2023 in constant 2021 prices, like in California, to which it is linked. However, the EU and Swiss ETS have experienced permit price increases in early 2023, though less strong than between 2021 and 2022. Within China, one third of pilots experienced a price increase, even though the national ETS has undergone a slight price decrease when expressed in constant 2021 prices. After experiencing one of the highest permit price increases between 2021 and 2022, New Zealand has experienced one of highest permit price decreases in early 2023. In Korea, after a relative stagnation of permit prices between 2021 and 2022, permit prices have plummeted in early 2023, decreasing to 2015-2016 levels (in current terms).

Table 3.3. Average permit price changes between 2021 and 2023

By ETS system

Emissions Trading System	Average 2021 permit price (in 2021 EUR/tCO ₂)	Change in average 2022 permit price (in 2021 EUR/tCO ₂) 2021-2022	Change in early 2023 permit price (in 2021 EUR/tCO ₂) 2022-2023
Alberta TIER	27	+ 27%	+ 20%
FOBPS: Manitoba, Nunavut, Ontario, Prince Edward Island, Saskatchewan, Yukon	27	+ 27%	+ 20%
New Brunswick OBPS	27	+ 27%	+ 20%
Newfoundland and Labrador PSS	27	+ 27%	+ 20%
Nova Scotia Cap-and-Trade	19	+ 20%	- 23% ⁽¹⁾
Quebec Cap-and-Trade	18	+ 36%	- 7%
Saskatchewan OBPS	27	+ 27%	+ 20%
Chinese national ETS	6	+ 31%	- 9%
Beijing Pilot ETS	8	+ 48%	+ 15%
Chongqing Pilot ETS	4	+ 35%	- 24%
Fujian Pilot ETS	2	+ 43%	+ 25%
Guangdong Pilot ETS	5	+ 102%	- 3%
Hubei Pilot ETS	4	+ 45%	- 4%
Shanghai Pilot ETS	5	+ 42%	- 3%
Shenzhen Pilot ETS	2	+ 169%	+ 66%
Tianjin Pilot ETS	4	+ 23%	- 10%
EU ETS	54	+ 37%	+ 2%
German nEHS	25	+ 12%	- 4%
Saitama Cap-and-Trade	4 ⁽²⁾	+ 3% ⁽²⁾	+ 2% ⁽²⁾
Tokyo Cap-and-Trade	4 ⁽²⁾	+ 3% ⁽²⁾	+ 2% ⁽²⁾

Kazakhstan ETS	1	+ 2%	NA ⁽³⁾
Korea ETS	17	- 2%	- 43%
Mexico Pilot ETS	0	0 %	NA ⁽⁴⁾
New Zealand ETS	30	+ 50%	- 17%
Switzerland ETS	45	+ 59%	+ 17%
UK ETS	60	+ 36%	- 12%
California Cap-and-Trade	19	+ 34%	- 6%
Massachusetts Limits on Emissions from Electricity Generators	6	+ 11%	+ 54%
RGGI	9	+ 48%	- 11%

Note: Unless otherwise specified, the table is based on average permit prices over 2021 and 2022, and early 2023 average permit prices. The inflation rate considered for the EU ETS is the average of inflation rates over all EU ETS countries considered in the report. Prices were converted into (constant) 2021 EUR using the latest available OECD exchange rate and inflation data.

1. Nova Scotia: two auctions a year take place. At the time of writing, the first 2023 had just taken place, on 7 June 2023.

2. Permit prices presented for Japan are the following: the 2021 permit price is estimated as the average between the December 2020 and the February 2022 permit prices; the 2022 permit price is the average between the February and the December 2022 permit prices; at the time of writing no information is available on 2023 permit prices, so December 2022 is used as a proxy for early 2023.

3. At the time of writing (as of May 2023), no information is available on secondary market permit prices for the Kazakhstan ETS.

4. At the time of writing (as of May 2023), no information is available on secondary market permit prices for the Mexico ETS.

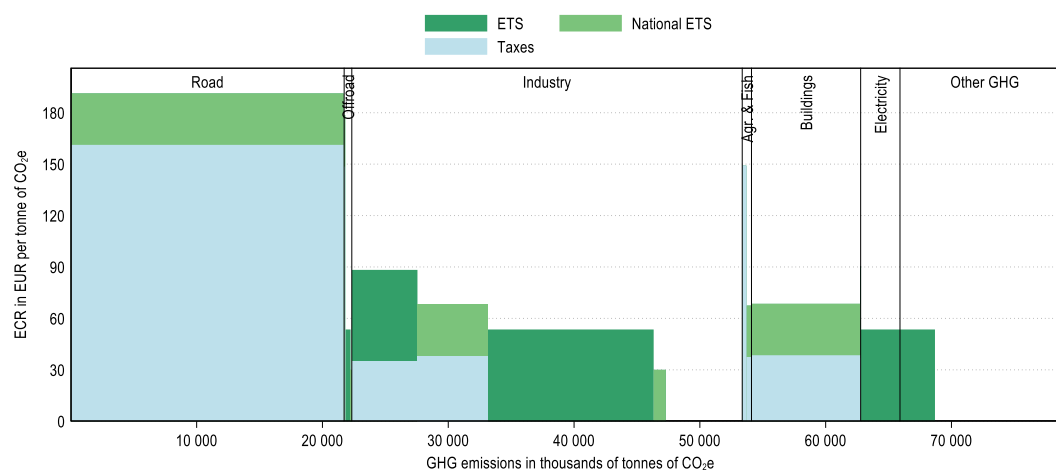
Source: ICAP allowance price explorer (ICAP, 2023^[23]), Nova Scotia Cap-and-Trade Program (2023^[24]), Mizuho Research & Technologies, Ltd. (2022^[25]), Government of Canada (2023^[26]), Government of Canada (2023^[27]), Greenhouse Gas Pollution Pricing Act (2023^[28]), Massachusetts Department of Environmental Protection (2023^[29]).

With 2021 ETS coverage and 2023 permit prices, the average permit price in countries subject to an ETS has increased by 41.7% (in constant 2021 EUR) since 2021. The increase in most permit prices has resulted in 24.7% emissions priced by ETSS reaching the benchmark rate of EUR 30/tCO₂ through permit prices only in 2023 and 18.3% the EUR 60/tCO₂ benchmark (up from respectively 15.4% and 1.2% in 2021): the increase in permit prices has brought about 17% of emissions priced through ETSS above the benchmark rate of EUR 60/tCO₂. As can be seen in Table 3.3, carbon pricing level progress implied by ETSS at a country level shows the most progress in Switzerland. Most EU ETS countries as well as Canada have also experienced significant progress with carbon pricing through ETSS in early 2023.

Between 2021 and 2023, three new ETSS were introduced or moved from a pilot to an implementation phase; they extend coverage of GHG emissions in sectors historically covered by ETSS such as electricity and industry, as well as to sectors usually mostly covered by taxes: transport and buildings. In 2022, Austria and the state of Oregon (United States) introduced ETSS which price transport, industry, electricity and buildings sectors. In 2023, the Mexican Pilot ETS is planned for moving to its operational phase,¹² and the state of Washington (United States) introduced a Cap-and-Trade program in January. These systems vary in their point of regulation (upstream for Austria and Oregon, mixed for Washington and downstream for Mexico) and in the sectors they cover (see Figure 3.4 and Figure 3.5).¹³ In Austria, this has increased the share of national GHG emissions covered by an ETS by about 47 percentage point (going from about 31% to 78%¹⁴), in Mexico by 40¹⁵ percentage points (starting from no ETS coverage) and in the United States (US), through the two state initiatives, by 1.5%. This scaling up of coverage is aligned with the headline statements of the AR6 Synthesis Report of the IPCC, which stresses how “regulatory and economic instruments can support deep emissions reductions and climate resilience if scaled up and applied widely” (IPCC, 2023^[30]).

Figure 3.4. Austria ECR

2021, using 2022 coverage for Austria's national ETS

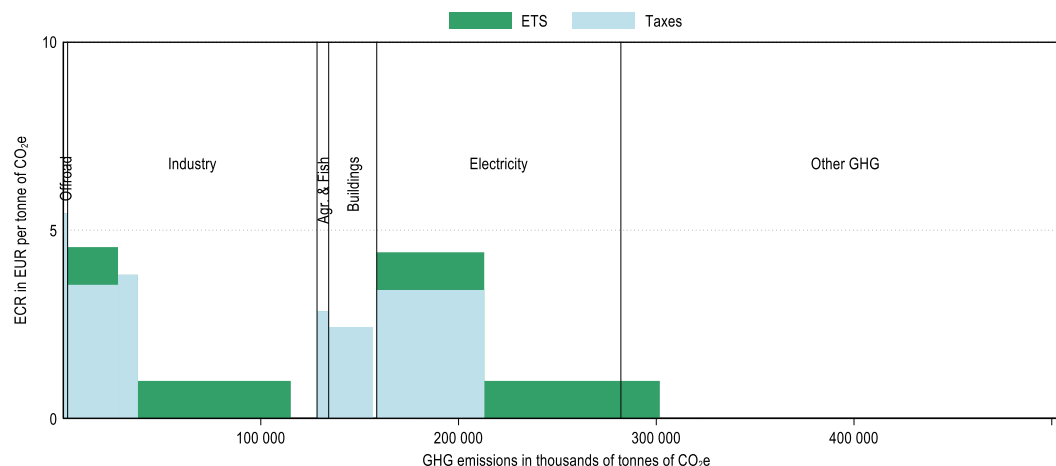


Note: This ECR profile presents the coverage and rates that Austria's national ETS would have implied, had it been in place in 2021 (with its 2022 permit price). Taxes stand for fuel excise and carbon taxes. In Austria, however, this category only refers to fuel excise taxes as it has no carbon tax in 2021. ETS coverage was estimated using information available on the Austrian Federal Chancellery homepage (bka.gv.at), RIS - Nationales Emissionszertifikatehandelsgesetz 2022 - Bundesrecht konsolidiert, Fassung vom 23.05.2023). Other GHG emissions data are from CAIT (Climate Watch, 2022^[31]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[32]).

StatLink  <https://stat.link/bhpzfd>

Figure 3.5. Mexico ECR

2021, using 2023 coverage for Mexico's ETS



Note: This ECR profile presents the coverage that Mexico's ETS for 2023 would have implied had it been in place in 2021. The permit price is set at a symbolic EUR 1/tCO₂ to highlight ETS coverage. The road transport sector is left out of this graph for readability purposes. In Mexico, more than 99.9% of emissions in the road transport sectors are priced through fuel excise, at an average of EUR 85.1 per tonne of CO₂. ETS coverage was estimated using information from the latest International Carbon Action Partnership *Emissions Trading Worldwide* status report (ICAP, 2023^[1]). Other GHG emissions data are from CAIT (Climate Watch, 2022^[31]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[32]).

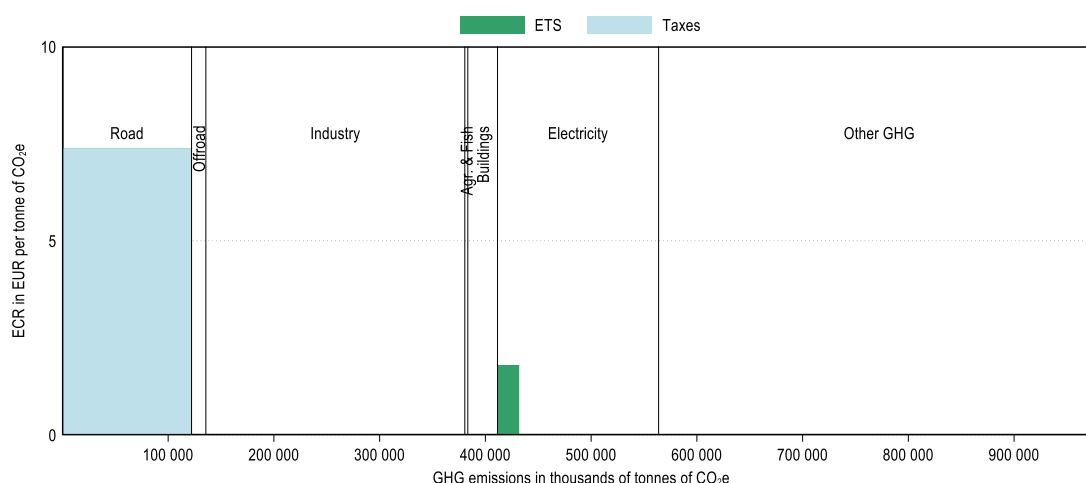
StatLink  <https://stat.link/jb1xd0>

In 2022, five countries had established a mandate for a country-level ETS and were drafting rules for it (ICAP, 2022^[8]). Two of these were in South East Asia (Indonesia and Vietnam), two in the Europe and

Central Asia region (Montenegro and Ukraine) and one in Latin America (Colombia).¹⁶ Indonesia launched its intensity-based ETS for the power generation sector on 22 February 2023 (MEMR, 2023^[33]), which introduces carbon pricing in its electricity sector (covering 13.5% of it), making it the second sector after road transport in the country to be covered by a carbon pricing instrument (Figure 3.6). Ukraine introduced a Monitoring, Reporting and Verification law in 2021 and its ETS may be launched by 2025 (ICAP, 2023^[1]). The ETS would bring coverage of the industry sector from about 50% through fuel excise and carbon taxes to 87% with the ETS. Electricity sector CO₂ emissions are currently already fully covered through effective carbon taxes, and the ETS would add on to those (Figure 3.7). Depending on permit price levels, the Ukrainian ETS could increase carbon prices in both the electricity and industry sectors, which in 2021 faced average ECRs implied by taxes of less than EUR 0.5/tCO₂.

Figure 3.6. Simulated Indonesia ECR profile

Simulation of the Indonesia ECR profile if its ETS were in place in 2021

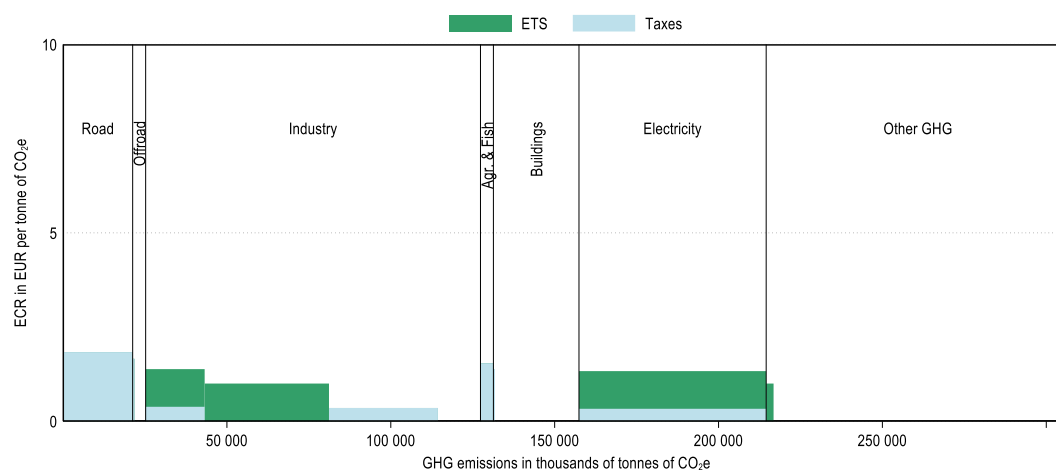


Note: This ECR profile presents the coverage that Indonesia's ETS would have implied had it been in place in 2021. The permit price of EUR 1.8/tCO₂ is an estimation based on the previously announced carbon tax for emissions exceeding a certain threshold (Otoritas Jasa Keuangan, 2023^[34]; ICAP, 2022^[35]). Coverage was estimated using information from Reuters (2023^[36]) and ICAP (2023^[1]). Other GHG emissions data are from CAIT (Climate Watch, 2022^[31]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[32]).

StatLink  <https://stat.link/70rfk6>

Figure 3.7. Simulated Ukraine ECR profile

Simulation of the Ukraine ECR profile if its ETS were in place in 2021



Note: This ECR profile presents the coverage that Ukraine's planned ETS would have resulted in had it been in place in 2021. The permit price is set at a symbolic EUR 1/tCO₂ to highlight ETS coverage. Coverage was estimated using information from the Cabinet of Ministers of Ukraine (2020^[37]). Other GHG emissions data are from CAIT (Climate Watch, 2022^[31]) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[32]).

StatLink  <https://stat.link/w62e3s>

In December 2022, the European Council and the European Parliament reached a provisional agreement on the introduction of an EU ETS 2 for emissions from fuels used in buildings, road transport and certain industrial sectors not already covered by the existing EU ETS, with compliance obligation to start in 2027 (European Parliament Press Room, 2022^[38]).¹⁷ Contrary to the current EU ETS, this ETS is to apply upstream, i.e. to fuel distributors. The introduction of the EU ETS 2 could increase road transport and building sectors coverage by up to 2.2% in the sample of 72 countries considered here and coverage of these sectors within EU ETS countries by up to 11.8%.¹⁸

New Zealand aims to introduce an emissions pricing scheme from 2024-25. Emissions will be priced via a farm-level split-gas levy, in which emissions from biogenic methane and long-lived gases (nitrous oxide and carbon dioxide) will be priced separately. The scheme will begin with mandatory reporting in the fourth quarter of 2024, followed by mandatory pricing in the fourth quarter of 2025. In line with this, the provisions in the Climate Change Response Act which oblige animal farmers to enter the NZ ETS from 1 January 2024 have recently been deferred; this will give the Government sufficient time to implement the alternative farm-level levy system. Political, social, food security and competitiveness concerns were raised during the process of introducing carbon pricing in this sector, whose emissions have so far generally been unpriced. The sector holds an important place in the country's economy and contributes to about 50% of New Zealand's GHG emissions.

Beyond these concerns, carbon pricing in this sector needs careful administrative and accounting design. Indeed, emissions measurement here is less straightforward than for CO₂ emissions from energy use, which may rely on fuel use. New initiatives are emerging to measure non-CO₂ emissions through satellite data¹⁹, though the quality and reliability of such data can be highly variable. The consultation document released in October 2022 by the New Zealand Ministry for the Environment and Ministry for Primary Industries (2022^[39]) relies on a model for emissions measurement which accounts for farm area, stock reconciliation, livestock production data and total synthetic nitrogen fertiliser use. Moreover, pricing non-energy related emissions in the agricultural sector can also require including Agriculture Forestry and Other

Land Use (AFOLU) considerations in the emissions accounting design (see Box 2.4 of OECD (2022^[40])). The report released by the Ministry for the Environment and the Ministry for Primary Industries in December 2022 supports the principle of recognising all scientifically valid forms of on-farm sequestration being rewarded through the NZ ETS, or alternative appropriate mechanism for rewarding carbon removals (Ministry for the Environment and Ministry for Primary Industries, 2022^[41]; He Waka Eke Noa, 2022^[42]).

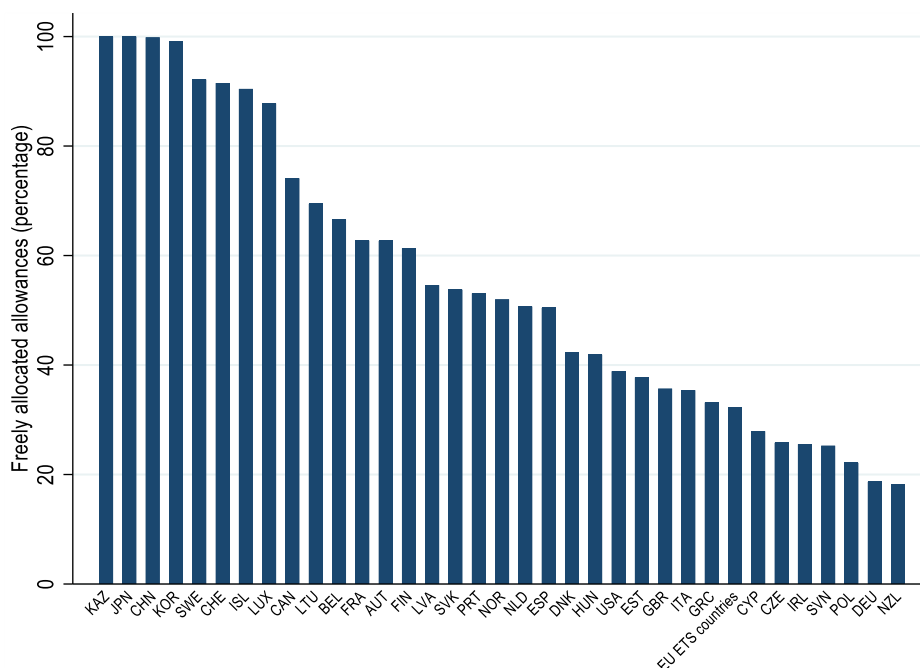
Accounting for affordability, social and political concerns can be key for the successful introduction of carbon pricing schemes in new sectors, especially the agricultural sector. In many countries, climate mitigation and reaching net-zero goals depends to a large extent on reducing GHG emissions in this sector (Figure 2.5, Figure 2.6). The current process taking place in New Zealand highlights the importance of accompanying farmers through the transition, of enabling them to measure their emissions²⁰ and of proposing substitution possibilities – that is, viable solutions to decrease their emissions. For example, the promotion of new technologies and of better farming practices can provide options for farmers to switch to less emitting practices. Henderson and Verma (2021^[43]) show that carbon taxes in the agricultural sector reduce global GHG emissions provided producers facing the tax can make use of GHG abatement technologies. The New Zealand proposal also includes payments to farmers using approved mitigation technologies or approved on-farm vegetation. For long-term purposes the proposal also includes revenue recycling to partly fund R&D to lower on-farm emissions (see OECD (2023^[44])).

3.4. Free allocation

Most emissions trading systems distribute part or all of emissions allowances for free, at least during the inception phase. Auctioning or fixed price selling of allowances is generally gradually introduced into systems as they become more mature. In 2021, the share of free allocation of allowances varies widely across systems, ranging from a 100% in Japanese ETSs, for instance, to almost 0% in RGGI and the Massachusetts Limits on Emissions from Electricity Generators (310 CMR 7.74).²¹ Some systems have a provision for auctions to take place even when in practice most allowances are allocated for free. For instance, all Chinese pilot ETSs have the possibility of organising auctions, but only half of them held auctions in 2021 (Chongqing, Hubei, Shanghai and Tianjin). The shares of free allocation of allowances in total verified emissions are presented by country in Figure 3.8.

Figure 3.8. Share of free allocation of allowances in total verified emissions by country

2021, for countries in which an ETS operates with a positive permit price



Note: EU ETS applies to all EU countries as well as Iceland, Liechtenstein and Norway. The ECR database in this report does not cover Bulgaria, Croatia, Liechtenstein, Malta and Romania, so these are not presented in this figure and the overall share over EU ETS countries does not include them either. Mexico's pilot ETS is not presented here because prices were null in 2021. Canada, China, Japan and the United States each have sub-national ETSs (along with the national ETS for China), and the resulting country-level shares of free allocation of allowances in total verified emissions are presented here.

StatLink  <https://stat.link/qyrmbc>

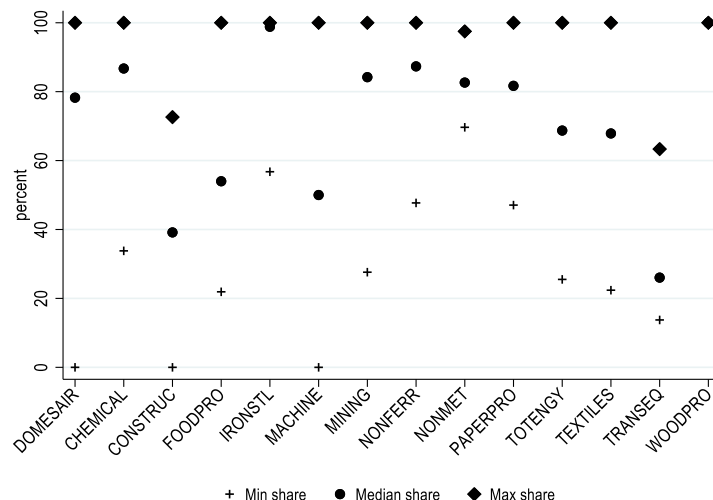
Most emissions trading systems are introduced with a high share of free allocation, for reasons including competitiveness and carbon leakage concerns as well as to build support from covered entities or sectors more generally. Allocating free allowances can ease the transition for industries with carbon-intensive processes into an ETS. They can also be used to protect firms against competitiveness losses and to avoid carbon leakage. Indeed, for trade-exposed industries, higher carbon prices due to the introduction of an ETS in one jurisdiction can induce a shift in production and investment to areas with less stringent climate policies. This in turn can hurt the domestic economy without reducing global emissions. Even though the evidence for carbon leakage and competitiveness impacts is mixed and in general of small amplitude (see Annex 3.A), it relies on past policies, when carbon prices were lower and widespread exemptions and free allocation (Ellis, Nachtigall and Venmans, 2019^[45]; OECD, 2020^[46]). As efforts are being ramped up to reach 2030 and 2050 goals, it is important to acknowledge that carbon leakage and competitiveness impact may be more significant.

In the EU ETS, the variability in the share of free allowances in total verified emissions across countries may be explained by countries' sectoral compositions. The share of free allocation has substantially decreased since the introduction of the EU ETS. In 2010, almost no verified emissions faced compliance through auction, while in 2021, about 60% of verified emissions were covered through auctions. The country-level variation in free allocation by industrial subsector (other than heat sold to third parties and autogeneration of electricity) and for domestic aviation is presented in Figure 3.9. Industrial subsectors for which at least half of EU ETS countries receive more than 80% share of free allocation in verified emissions

include the chemical subsector, mining, non-ferrous metals and non-metallic minerals subsectors, as well as paper production. In iron and steel, half of EU ETS countries receive more than 98% of free allocation, while in wood production, almost all countries receive 100% of free allocation. In general, these are energy intensive trade exposed (EITE) industries. Four of these sub-sectors are to be covered by the EU Carbon Border Adjustment Mechanism (CBAM) – for which an agreement was finalised in April 2023, and which was adopted in May 2023: iron and steel, cement (part of non-metallic minerals), fertilisers (part of the chemical industry) and aluminium (part of non-ferrous metals) (European Commission, 2023^[47]).

Figure 3.9. Free allocation by industrial subsector and aviation in the EU ETS

2021



Note: DOMESAIR stands for “domestic aviation” and belongs to the off-road transport sector. The other subsectors presented in this figure all belong to the industry sector. CHEMICAL stands for “chemical and petrochemical”, CONSTRUC for “construction”, FOODPRO for “food production”, IRONSTL for “iron and steel”, MACHINE for “machinery”, MINING for “mining and quarrying”, NONFERR for “non-ferrous metals”, NONMET for “non-metallic minerals”, PAPERPRO for “paper, pulp and print”, TOTENGY for “energy industry own use”, TEXTILES for “textile and leather”, TRANSEQ for “transport equipment” and WOODPRO for “wood and wood products”. “Min share” (resp. “Max share”) represents the minimal (resp. maximal) sub-sectoral country-level share of free allocation of allowances in verified emissions observed in EU ETS countries in the sample. The median share represents the value such that 50% of countries have a share of free allocation of allowances in verified emissions above (or below) this value for that sub-sector. For instance, “Median share” for CHEMICAL can be interpreted as follows: at the country level, the chemical and petrochemical industry covered by the EU ETS receives more than 86% of free allocation in 50% of the 25 EU ETS countries covered in the sample. When freely allocated allowances are greater than verified emissions (overallocation of free allowances), the share was normalised to 1 (or 100%).

StatLink  <https://stat.link/ol1s35>

Emissions allowances may be freely allocated using grandfathering, benchmarking or an output-based approach, with the first two being more common (see Table 3.2). Grandfathering adopts a historical approach: installations receive allowances based on their emissions in a base year or period. Benchmarking uses efficiency benchmarks: installations receive allowances based on performance indicators (e.g., the amount of allowances received by an installation can be determined by a certain share of the most efficient installations in a sector).

Grandparenting and benchmarking as allocation rules differ in many ways, including: 1) in the ease of calculation they offer; 2) in the incentives to reduce emissions they provide; and 3) in the smooth transition into carbon pricing they enable.

Using grandfathering as an allocation rule in the early stages of an ETS reduces initial costs, as installations receive a level of free allocation close to their pre-existing level of emissions. However, the base year or period should be set sufficiently back in time to avoid providing incentives to firms to increase

emissions before the implementation of the ETS to increase the allocation they receive. At the same time, the base year should not be set too far back in time so that emissions estimations used to calculate allocation amounts are in line with current technologies and abatement opportunities. While relatively straightforward to calculate, grandparenting tends to provide more support to historically high emitters.

Benchmarking can make the transition into an ETS harder for emissions-intensive firms and can require more complex calculations as it relies on detailed production and emissions data at the firm or product level to develop sectoral benchmarks. However, it removes the link between historical emissions and allocation and rewards best performers, hence generating higher abatement incentives. In general, grandparenting tends to be found more frequently in earlier phases of ETSs, with a move to benchmarking as the system evolves (Kuneman et al., 2022^[48]). For instance, since 2020, benchmarking is used in the Beijing Pilot ETS for new entrants and installations in heat production, cement, and data centres (ICAP, 2023^[1]).

While free allocation of allowances does not affect the marginal price signal, it does affect the average price signal, which in turn affects economic rents and thus can influence investment decisions. Free allocations do not change the marginal price signal faced by firms because even if entities receive free allocations, reducing their emissions allows them to sell extra permits while emitting more requires them to buy additional permits. And even if they emit exactly what they have been allocated, they face an opportunity cost as they forgo the income they would have gotten from reducing their emissions and selling those extra permits. However, the average²² price paid by entities for permits does depend on the level of free allocation received. Flues and Van Dender (2017^[15]) show that permit allocation rules affect economic rents and that in practice they tend to do so in a way that favours more carbon-intensive technologies.

As ETS caps are tightened, however, the potentially negative impact of free allocation on mitigation incentives decreases. Indeed, the tightening of a cap involves reducing space for free permits, as compliance then increasingly takes the form of abatement as opposed to relying on free allocation of allowances. A lower cap requires lower emission levels, so even if the share of free allocation of allowances does not change, its level does.

Free allocation can result in windfall profits in certain sectors. The mechanism is that even when receiving free allocation of allowances, firms still face opportunity costs, i.e. the marginal cost of carbon. If they can then pass-through this cost to consumers, the free allocation becomes a rent. In practice, this depends on many factors, including the allocation regime, the competition in the sector, demand and supply elasticities, carbon intensity of production, and international trade exposure of the sector (Quirion, 2007^[49]; Hobbie, Schmidt and Möst, 2019^[50]). These factors impact pass-through of carbon costs to consumer prices.

Evidence for high windfall profits of firms receiving free allowance allocation has been found in the power sector, as this sector is less exposed to international competition (e.g. Sijm, Neuhoof and Chen (2006^[51]), Mercantonini et al. (2017^[52])). Since 2013, free allocation for power sector installations has been almost entirely phased out in the EU ETS. RGGI and the Massachusetts 310 CMR 7.74 apply exclusively to the power sector and predominantly rely on auctioning. Following the same logic, it is argued that since the buildings and road transport sectors face no or low international competition and carbon leakage risk, allowances for these sectors should be solely allocated through auctioning under the EU ETS 2 (Council of the European Union, 2023^[53]) (see section 3.3 for additional information on the EU ETS 2). Finally, the extent of the impact on rents may depend on the allocation regime, with benchmarking, if well designed, potentially inducing less windfall profits (Quirion, 2007^[49]).²³

Free allocation may also have equity impacts, whether among firms or between producers and consumers. Indeed, free allocation reduces average costs for installations receiving them, which may give them an advantage over installations ineligible for free allocation. This can also have an impact across regions, depending on the geographical composition of industries within a country (IEA, 2020^[54]). Moreover, in the case of full cost pass-through, free allocation favours the producer at the expense of the consumer (Sijm et al., 2008^[55]).

At a global level, the share of free allocation differs across sectors (Table 3.4). In the electricity and industry sectors, whose emissions are predominantly priced through ETSs (Figure 2.3), respectively 88% and 84% of allowances are allocated for free. Hence, while the average permit prices, hence the marginal price signals in ETS-covered electricity and industry are of EUR 11.54/tCO₂ and EUR 27.14/tCO₂, the average price signal in these sectors is muted.

Table 3.4. Total share of free allocation in countries' sectors subject to ETSs

2021, for countries in which an ETS operates with a positive permit price

Sector	Share of free allocation (in percentage)	Average permit price (in EUR/tCO ₂)
Agriculture & fisheries	19%	23.40
Buildings	39%	21.16
Electricity	88%	11.54
Industry	84%	27.14
Off-road transport	77%	25.20
Road transport	2%	20.90

Note: The 34 countries included in the overall shares presented in this table are: Austria, Belgium, Canada, China, Cyprus, Czechia, Germany, Denmark, Estonia, Finland, France, Greece, Hungary, Ireland, Iceland, Italy, Japan, Kazakhstan, Korea, Latvia, Lithuania, Luxemburg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, the United States. The average permit price is the emissions-weighted average permit price over ETS-covered emissions.

The wedge created by free allocation of allowances between the marginal and average carbon prices may be captured using either the share of free allocation incurred by an installation, subsector, sector or country (e.g. Table 3.4) but it may also be captured by the Effective Average Carbon Rates (EACR) and Effective Marginal Carbon Rates (EMCR) indicators (e.g. Table 3.5). The EMCR is the main indicator used in this report: the ECR summarises the *marginal* carbon rates faced by subsectors, sectors or countries. The EACR, on the other hand, summarises the *average* carbon rates faced by subsectors. The EMCR thus represents the strength of the marginal incentive to reduce emissions while the EACR represents the strength of the incentives to invest in clean technologies (see Box 4.1, OECD (2021^[18])).

In line with ETSs being the main pricing instrument in the electricity and industry sectors (Figure 2.3), these are the two sectors where the discrepancy between EMCRs and EACRs is the highest (Table 3.5). Off-road transport, which is also covered by some ETSs through aviation emissions pricing, can also present a non-negligible gap between marginal and average carbon prices. The discrepancy between EMCR and EACR varies with the share of free allocation in the ETS systems countries face as well as the share of the sector's emissions priced through ETSs. For instance, even though Japan allocates 100% of allowances for free, given that about 1.7% of its emissions are priced through the Tokyo and Saitama Cap-and-Trade systems (Figure 3.1), the high share of free allocation hardly lowers the EACR. In most countries or supranational jurisdictions, however, the EACR is at least halved as compared to the EMCR in the industry and electricity sectors. This can have important impacts on long-run investment in decarbonisation in these sectors, which represent an important share of global emissions (Figure 3.3) and will be key in reaching net zero objectives.

Table 3.5. EMCRs and EACRs in countries or supranational jurisdictions with an ETS

2021 in EUR.

Country or supranational jurisdiction	Sector	ETS marginal permit price	ETS average permit price	ETS coverage in the sector	Share of free allocation in the ETS	EMCR	EACR
Canada	Agriculture	18.8	16.98	16.4%	9.30%	18.74	18.44
	Buildings	18.76	17.81	7.1%	4.90%	30.65	30.58
	Electricity	26.49	10.92	94.0%	59.20%	24.94	10.3
	Industry	25.89	3.92	72.9%	83.40%	21.5	5.47
	Off-road transport	18.77	17.65	6.8%	5.80%	33.28	33.2
	Road transport	18.83	16.45	14.3%	12.20%	91.64	91.3
China	Agriculture	n.a.	n.a.	n.a.	n.a.	35.92	35.92
	Buildings	5.91	0.07	3.4%	98.80%	4.88	4.68
	Electricity	5.91	0	100.0%	100%	5.92	0.01
	Industry	5.91	0.07	10.0%	98.80%	1.44	0.85
	Off-road transport	5.91	0.07	8.9%	98.80%	31.92	31.41
	Road transport	n.a.	n.a.	n.a.	n.a.	68.89	68.89
EU ETS*	Agriculture	53.54	39.11	0.3%	26.90%	47.91	47.87
	Buildings	53.54	40.67	0.8%	25.50%	57.46	57.36
	Electricity	53.54	52.41	99.5%	2.10%	53.87	52.75
	Industry	53.54	15.52	66.7%	71.00%	44.71	19.36
	Off-road transport	53.54	11.41	33.7%	82.30%	33.89	19.69
	Road transport	n.a.	n.a.	n.a.	n.a.	197.08	197.08
Germany	Agriculture	25	25	100.0%	0%	115.72	115.72
	Buildings	25.08	25.02	98.8%	0.10%	53.5	53.45
	Electricity	53.54	52.21	100.0%	2.50%	53.54	52.21
	Industry	49.09	21	86.9%	52.50%	47.12	22.7
	Off-road transport	29.9	23.29	99.5%	12.30%	92.41	85.84
	Road transport	25	25	100.0%	0%	236.45	236.45
Japan	Agriculture	n.a.	n.a.	n.a.	n.a.	0	0
	Buildings	4.39	0	0.8%	100%	20.28	20.25
	Electricity	4.39	0	3.0%	100%	5.52	5.38
	Industry	4.39	0	1.3%	100%	3.86	3.8
	Off-road transport	n.a.	n.a.	n.a.	n.a.	26.27	26.27
	Road transport	n.a.	n.a.	n.a.	n.a.	154.08	154.08
Kazakhstan	Agriculture	n.a.	n.a.	n.a.	n.a.	0.03	0.03
	Buildings	n.a.	n.a.	n.a.	n.a.	0.01	0.01
	Electricity	1	0	100.0%	100%	1	0
	Industry	1	0	73.8%	100%	0.74	0

	Off-road transport	n.a.	n.a.	n.a.	n.a.	0.02	0.02
	Road transport	n.a.	n.a.	n.a.	n.a.	0.25	0.25
Korea	Agriculture	n.a.	n.a.	n.a.	n.a.	0	0
	Buildings	17	1.25	47.2%	92.70%	29.08	21.65
	Electricity	17	0.46	92.1%	97.30%	30.5	15.26
	Industry	17	0	100.0%	100%	21.43	4.43
	Off-road transport	17	0	68.4%	100%	16.72	5.09
	Road transport	17	0	3.0%	100%	168.29	167.79
New Zealand	Agriculture	29.55	27.91	98.9%	5.50%	31.16	29.54
	Buildings	29.55	29.55	99.6%	0%	29.85	29.85
	Electricity	29.55	29.55	100.0%	0%	29.55	29.55
	Industry	29.55	17.13	99.8%	42.00%	29.67	17.27
	Off-road transport	29.55	29.55	98.8%	0%	30.08	30.08
	Road transport	29.55	29.55	98.8%	0%	129.46	129.46
Switzerland	Agriculture	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
	Buildings	n.a.	n.a.	n.a.	n.a.	89.7	89.7
	Electricity	45.01	35.82	1.0%	20.40%	79.29	79.2
	Industry	45.01	4.72	33.4%	89.50%	41.95	28.5
	Off-road transport	45.01	0	9.8%	100%	281.12	276.7
	Road transport	n.a.	n.a.	n.a.	n.a.	292.69	292.69
United Kingdom	Agriculture	60.03	60.03	0.4%	0%	30.8	30.8
	Buildings	60.03	52.66	0.5%	12.30%	7.45	7.42
	Electricity	60.03	59.94	97.9%	0.14%	77.05	76.97
	Industry	60.03	22.38	54.5%	62.70%	43.52	23
	Off-road transport	60.03	0	23.3%	100%	31.63	17.66
	Road transport	n.a.	n.a.	n.a.	n.a.	266.52	266.52
United States	Agriculture	15.79	0	4.7%	100%	0.74	0
	Buildings	15.79	0	6.0%	100%	0.95	0
	Electricity	15.79	11.55	10.5%	26.90%	1.65	1.21
	Industry	15.79	1.36	6.3%	91.40%	1.01	0.1
	Off-road transport	15.79	8.57	0.8%	45.70%	7.56	7.5
	Road transport	15.79	15.79	9.0%	0%	46.23	46.23

Note: n.a. not applicable. Free allocation shares greater than 1 were normalised to 1. The EACR is also calculated following this standardisation. EMCR and EACR are averaged across all emissions in a sector, including those emissions that are not covered by any carbon pricing instrument. ETS prices are conditional averages weighted by the emissions covered by the operational systems identified in a given sector. *The EU ETS here is considered without Germany, which has its own ETS. German ETS coverage in this table is meant as coverage by the EU ETS and the nEHS.

In contrast with free allocations, selling allowances (generally through auctions) has several advantages including raising revenue, better reflecting the need of installations for allowances, being simpler to administer than free allocation and ensuring more equity between installations. The sale of permits in the primary market (i.e. through auctioning or fixed price sales) as opposed to exchanges on the secondary market has the benefit of raising revenue for the government. Selling allowances enables to better reflect the need of installations for allowances in many ways. First, a considerable amount of overallocation can be found in many ETSs. For example, in 2019, 2020 and 2021, about 20% of EU ETS installations received more free allocation than the previous year reported emissions (Joltreau and Sommerfeld, 2019^[56]). Hence, selling allowances can enable more coherence between permit possession and GHG emissions. Second, auctioning can allow price discovery other than through the secondary market, in a more transparent manner too as auction reports are generally published and publicly available.²⁴ Moreover, while demanding a careful design, auctions can be administratively simpler than alternative free allocation approaches, as less data demanding. Finally, selling allowances can ensure more equity, as it provides entities covered by the ETS equal opportunities to buy allowances.

Revenues raised from selling allowances can be used to address distributional and affordability impacts of carbon pricing, to invest in further mitigation action through various means and to fund the general budget. In sectors where cost pass-through is high, so that the increase in carbon prices translates into higher prices for consumers, the revenue can be used to support lower-income households. In the California Cap-and-Trade system, 85% of the revenues from auctions in the power sector are used to offset customer cost increases (IEA, 2020^[54]). The new Social Climate Fund to be introduced alongside the EU ETS 2 would receive part of the revenues from the allowance sales, to be used to support vulnerable households and micro-enterprises.

The revenue can also be used to support firms in the transition, for example by encouraging investment in green technologies. For example, a share of the EU ETS auction revenue is dedicated to its Innovation and Modernisation Funds, which were established in Phase 4 to support decarbonisation in EU ETS sectors. The Innovation Fund is meant to support the commercial demonstration of innovative low-carbon technologies and industrial solutions to decarbonise Europe's energy-intensive industries. It can also support the development of renewable energy, energy storage, and carbon capture use and storage. The Modernisation Fund is meant to support investments in ten lower-income EU member states to help modernise energy systems, improve energy efficiency, and address social issues in the path to net-zero emissions (ICAP, 2023^[1]). In Canada, proceeds collected from the output-based pricing system are to be used, at least in part, to help decarbonize industrial sectors (Environment and Climate Change Canada, 2020^[57]). Subsidies and green tax incentives to encourage firms' transition to net-zero emissions are increasingly being discussed.

While auctioning of allowances can present many advantages, careful consideration should go into their design and participation rules. Indeed, well-designed rules can help avoid manipulation through collusive behaviour of groups of bidders and limit the market power of single large buyers (ICAP, n.d.^[58]). Depending on their design, auctions can also help dilute market power in the secondary market (Alvarez and Andrr, 2013^[59]). RGGI, in which auctioning is the main way allowances may be acquired, presents market reports for each auction, which assess the auction process, and make sure there were no barriers to participation in the auction nor concerns related to the competitiveness of the auction results (e.g. Potomac Economics (2021^[60])).

Finally, even with careful use of revenues, competitiveness and carbon leakage arising from asymmetric carbon mitigation efforts and lack of international coordination can remain an issue. An alternative to free allocation can be to implement a border carbon adjustment (BCA). Energy-intensive-trade-exposed (EITE) industries have lower ability to pass production cost increases into higher consumer prices than certain sectors such as power and transport. There is evidence for direct cost increases between 5 and 10 percent for aluminium and steel and up to 30 percent for cement (Black, Zhunussova and Parry, 2022^[61]). Those industries hence typically do not receive windfall profits from free allocation but might experience

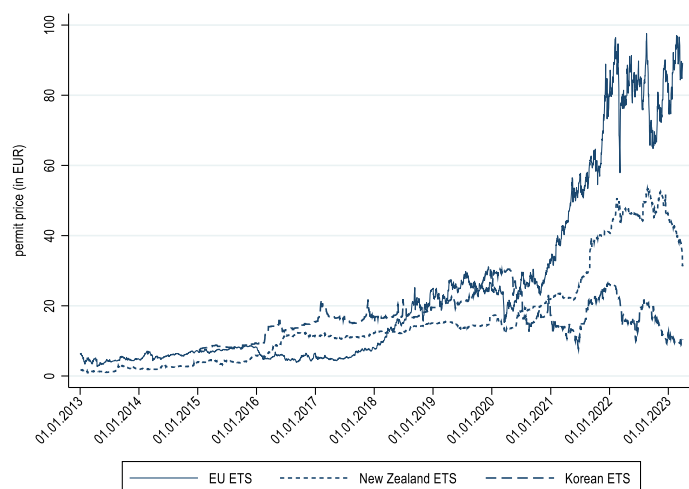
international competitiveness pressure and incentives to relocate activities if facing full auctioning of allowances. BCAs, which impose a levy on embodied carbon in imports net of pricing on those emissions by the country of origin, can help ease the phase-out of free allocation (OECD, 2020^[46]). This is the current approach of the EU Carbon Border Adjustment Mechanism (CBAM), which is meant to address the risk of carbon leakage for EU ETS firms while phasing out free allocations (ICAP, 2022^[35]; Official Journal of the European Union, 2023^[62]). Canada and the United Kingdom are also considering the introduction of BCAs (Clausing and Wolfram, 2023^[63]; Government of Canada, 2021^[64]; HM Treasury and Department for Energy Security, 2023^[65]).

The substitutability of free allocation and border carbon adjustments, however, is not entirely straightforward, given potential issues related to the complexity of design and measurement, “reshuffling” of emissions, and potential trade wars (OECD, 2020^[46]; Clausing and Wolfram, 2023^[63]; Van Dender and Raj, 2022^[66]). While the phasing out of free allocation in energy-intensive sectors strengthens incentives for marginal emissions abatement and induces the deep structural change that is needed to reach net zero emissions by mid-century, the potential for BCAs to address the resulting competitiveness impacts warrants some of the following considerations to ensure its effectiveness. These include the alignment of industries to which the BCA would apply and for which free allocation would be phased out, supply chain concerns, international competitiveness of exporting firms, difficulties in measuring carbon content, emissions reshuffling and the possibility of trade wars. As an alternative measure, clean energy subsidies can support the phase-out of free allocation in EITE sectors (Clausing and Wolfram, 2023^[63]).

3.5. Price stability mechanisms

Permit prices have been increasing in a majority of ETSs (see Table 3.3) but primary and secondary markets prices tend to be volatile (see Figure 3.10). This affects long-term planning for firms and results in uncertainty for investors. Mechanisms aimed at providing price stability exist in many jurisdictions (Table 3.6).

Figure 3.10. Permit price volatility in selected ETSs



Note: This figure shows permit price volatility in the EU ETS, the Korean ETS and New Zealand ETS as secondary markets transactions for those systems are logged and take place at a sufficiently high frequency to highlight price volatility.

Source: ICAP allowance price explorer (<https://icapcarbonaction.com/en/ets-prices>).

Volatility of permit prices affects investors' decisions and capacity for firms to plan. Indeed, investments in infrastructure and renewable energies require long time horizons. For instance, the horizon for investment in wind and solar power often exceeds 20 years. Hence, since investors need to form expectations about carbon prices over the entire lifetime of their investment, current carbon prices at the time of investment are only one piece of the information they need to make an investment decision (Flues and van Dender, 2020^[6]). In this context, price uncertainty may reduce incentives to carry out long term investments required to reach net-zero goals. Berestycki et al. (2022^[67]) show that more generally, climate policy uncertainty is associated with decreases in investment, particularly in pollution-intensive sectors that are most exposed to climate policies, and among capital-intensive companies.

Many ETSs have price stability mechanisms provisions (Table 3.6), which can help guarantee a minimum return on clean investment. These price stability mechanisms can be classified into measures that directly stabilise carbon prices, such as carbon price floors or ceilings and measures that indirectly stabilise them, through permit supply adjustments for instance (Flues and van Dender, 2020^[6]). The EU ETS 2 discussions, for example, have planned to adapt the Market Stability Reserve to include an additional price stability mechanism to make sure that in the initial years of the ETS 2, prices do not exceed EUR 45 per tonne of CO₂.

Direct and indirect market price stabilisation mechanisms are relatively evenly distributed across jurisdictions with an ETS (Table 3.6) and may be aimed at the primary or the secondary market. Very few ETSs have no such mechanism, and in general when this is the case introducing one is being discussed. Some ETSs present multiple stabilisation mechanisms. In Chinese Pilot ETSs, which mostly rely on free allocation of allowances, permit price levels are generally determined by the secondary market. Hence, in these ETSs, price stabilisation mechanisms are mostly applied by exchange. Many systems which have a minimum price level provision also set a trajectory for this price, generally meant to be aligned with inflation. Finally, within the EU ETS, some countries unilaterally set a minimum price level in certain sectors (e.g. the UK before 2021 and the Netherlands since 2021). While some argue that this can lead to political fragmentation and carbon leakage within the EU, such initiatives can also be seen as a driver for other countries to follow suit (Flachsland et al., 2018^[68]). Flachsland et al. (2018^[68]) also propose solutions such as auction reserve prices to avoid compliance costs diverging too much between sectors within Europe.

Table 3.6. Price stability mechanisms

2023 Outlook for systems operational in 2021

Emissions trading system	Country	Price stability mechanism	Type of mechanism
Alberta TIER	Canada	Fixed price (CAD 65 in 2023) and offset credits admissible.	Direct stabilisation of permit prices
		If TIER regulation compliance costs exceed 3% of sales or 10% of profit at a facility, the owner of that facility may be eligible to receive relief under the Compliance Cost Containment Program.	Direct stabilisation of permit prices
FOBPS: Manitoba, Nunavut, Ontario, Prince Edward Island, Saskatchewan, Yukon	Canada	Excess emissions charge payments set at CAD 65 but also surplus and offset credits admissible.	Direct stabilisation of permit prices
New Brunswick OBPS	Canada	Fixed price (CAD 65 in 2023).	Direct stabilisation of permit prices
Newfoundland and Labrador PSS	Canada	Fixed price (CAD 65 in 2023) and performance credits admissible.	Direct stabilisation of permit prices
Nova Scotia Cap-and-Trade	Canada	In the first year of each compliance period, the government places 3% of allowances into a reserve, which can be used for cost containment. The	Direct stabilisation of

		allowances are offered for sale at set prices to participants to cover their compliance obligations. The initial price was set at CAD 50 in 2020, rising annually by 5% plus inflation.	permit prices
Quebec Cap-and-Trade	Canada	An auction reserve price sets the minimum price at which allowances are available at auction. It is equal to the annual minimum price of the previous year, increased by 5% and an indexation rate based on the Price Index Consumption (CPI). For 2023, it is set at CAD 20.83.	Direct stabilisation of permit prices
Saskatchewan OBPS	Canada	Fixed price (CAD 65 in 2023) and performance credits admissible.	Direct stabilisation of permit prices
Chinese national ETS	China	Mechanisms are being defined.	n.a.
Beijing Pilot ETS	China	The competent authority can auction extra allowances if the weighted average price exceeds CNY 150 for ten consecutive days and buy back allowances from the market if the price is below CNY 20.	Indirect stabilisation of permit prices
		The Beijing Green Exchange limits price increases and decreases for trading over the Exchange when they exceed or are below 20% of a reference price.	Direct stabilisation of permit prices
Chongqing Pilot ETS	China	No details available	n.a.
Fujian Pilot ETS	China	Five percent of the total cap is kept as a government reserve for market stabilization	Indirect stabilisation of permit prices
		High prices can trigger allowance auctions from government reserves through the Haixia Equity Exchange. Low prices may trigger authorities to buy allowances from the market through governmental funds	Indirect stabilisation of permit prices
Guangdong Pilot ETS	China	Five percent of allowances are set aside as government reserves for new entrants and market stability.	Indirect stabilisation of permit prices
		Auctions under the Guangdong Pilot ETS are subject to an auction reserve price.	Direct stabilisation of permit prices
Hubei Pilot ETS	China	Eight percent of the total cap is kept as a government reserve for market stabilization.	Indirect stabilisation of permit prices
		The Hubei Ecology and Environmental Bureau (EEB) can buy or sell allowances if the allowance price reaches a low or high point six times during a 20-day period.	Indirect stabilisation of permit prices
		The Exchange limits day-to-day price fluctuations to a 10% move in either direction.	Direct stabilisation of permit prices
Shanghai Pilot ETS	China	If prices vary by either 10% or 30% in one day, the Exchange can temporarily suspend trading or impose holding limits.	Indirect stabilisation of permit prices
		A small share of the annual cap can be kept in a reserve for auctioning before the end of the annual compliance cycle as a market stability measure.	Indirect stabilisation of permit prices
Shenzhen Pilot ETS	China	Two percent of the total cap is kept as a government reserve for market stabilization.	Indirect stabilisation of permit prices
		In case of market fluctuations, the Shenzhen EEB can sell extra allowances from the reserve at a fixed price. Such allowances can be used only for compliance and cannot be traded.	Direct stabilisation of permit prices
		The government can buy back up to 10% of the total cap.	Indirect stabilisation of permit prices
Tianjin Pilot ETS	China	In case of market fluctuations, the Tianjin EEB can buy or sell allowances (for a fixed price or through auctioning).	Indirect stabilisation of permit prices
EU ETS	EU countries and Iceland, Liechtenstein and Norway	The Market Stability Reserve (MSR) started operating in 2019 as a long-term measure to address a growing surplus of allowances in the EU ETS. It adjusts auction volumes according to pre-defined thresholds of the total number of allowances in circulation to foster a balance in the EU carbon	Indirect stabilisation of permit prices

		market and resilience to demand shocks.	
German nEHS	Germany	Fixed price until 2026, then price corridor.	Direct stabilisation of permit prices
Saitama Cap-and-Trade	Japan	None.	n.a.
Tokyo Cap-and-Trade	Japan	In general, covered facilities and other market participants trade over the counter, and the Tokyo Metropolitan Government does not control carbon prices. However, in the event of excessive price increase, it can sell its own offset credits on a discretionary basis.	Indirect stabilisation of permit prices
Kazakhstan ETS	Kazakhstan	No information available.	n.a.
Korea ETS	Korea	If certain triggers are reached, stabilization measures may be put in place, which include additional auctioning of up to 25% of allowances from the market stabilization reserve; the establishment of a limit to the number of allowances entities can hold; an increase or decrease of the borrowing limit; an increase or decrease of the offset limit; the temporary setup of a price ceiling or price floor.	Direct and indirect stabilisation of permit prices
Mexico Pilot ETS	Mexico	Not yet applicable.	n.a.
Netherlands	Netherlands	The Netherlands carbon levy acts as a mechanism that sets a minimum price on emissions in the industry sector covered by the EU ETS.	Direct stabilisation of permit prices
New Zealand ETS	New Zealand	If a predetermined trigger price is reached at auction, a specified number of allowances from the Cost Containment Reserve is additionally released for sale. The trigger price was originally set at NZD 50 in 2021 and scheduled to rise by 2% per year in line with projected inflation.	Indirect stabilisation of permit prices
		With the start of auctioning, the government introduced a price floor of NZD 20 for 2021-2025, scheduled to rise at 2% per year. The price floor operates through a reserve price or minimum accepted bid at auction. At the latest update, the price floor was set at NZD 33.06 as of 1 April 2023, set to rise to NZD 44.35 by 2027.	Direct stabilisation of permit prices
Switzerland ETS	Switzerland	A market stability mechanism was introduced in 2022 that reduces auction volumes if the quantity of allowances in circulation exceeds a certain threshold.	Indirect stabilisation of permit prices
UK ETS	United Kingdom	A Cost Containment Mechanism avoids spikes in allowance prices by auctioning additional allowances.	Indirect stabilisation of permit prices
		To ensure a minimum level of ambition in the transition from the EU ETS to the UK ETS, a transitional auction reserve price of GBP 22 is in place.	Direct stabilisation of permit prices
		The Carbon Price Support ensures a minimum level to permit prices in the UK power sector.	Direct stabilisation of permit prices
California Cap-and-Trade	United States	An auction reserve price is in place, which increases annually by 5% plus inflation, as measured by the Consumer Price Index (in 2023 it is of USD 22.21).	Direct stabilisation of permit prices
		Some allowances from each annual cap are placed in an Allowance Price Containment Reserve. Since 2021, these allowances have been placed into two price tiers and a price ceiling.	Direct stabilisation of permit prices
Massachusetts Limits on Emissions from Electricity Generators	United States	The auctions have a reserve price of USD 0.50 per allowance	Direct stabilisation of permit prices
RGGI	United States	RGGI has an auction price floor of USD 2.50 per short ton in 2023, increasing by 2.5% every year.	Direct stabilisation of permit prices
		Cost containment reserve consists of a quantity of allowances in addition to the cap, which are held in reserve and only released to the market when certain upper bound trigger prices are reached.	Indirect stabilisation of permit prices
		In 2021, RGGI started implementing an emissions containment reserve under which allowances are withheld from auction if certain lower bound trigger prices are reached	Indirect stabilisation of permit prices

Note: This table does not include mechanisms aiming at addressing quantity issues.

Source: ICAP (2023^[1]).

References

- Aldy, J. and W. Pizer (2015), “The Competitiveness Impacts of Climate Change Mitigation Policies”, *Journal of the Association of Environmental and Resource Economists*, Vol. 2/4, pp. 565-595, <https://doi.org/10.1086/683305>. [88]
- Alvarez, F. and F. Andrr (2013), “Auctioning vs. Grandfathering in Cap-and-Trade Systems with Market Power and Incomplete Information”, *SSRN Electronic Journal*, <https://doi.org/10.2139/ssrn.2362888>. [59]
- Arlinghaus, J. (2015), “Impacts of Carbon Prices on Indicators of Competitiveness: A Review of Empirical Findings”, *OECD Environment Working Papers*, No. 87, OECD Publishing, Paris, <https://doi.org/10.1787/5js37p21grzq-en>. [71]
- aus dem Moore, N., P. Großkurth and M. Themann (2019), “Multinational corporations and the EU Emissions Trading System: The specter of asset erosion and creeping deindustrialization”, *Journal of Environmental Economics and Management*, Vol. 94, pp. 1-26, <https://doi.org/10.1016/j.jeem.2018.11.003>. [82]
- Beiser-McGrath, L. and T. Bernauer (2019), “Could revenue recycling make effective carbon taxation politically feasible?”, *Science Advances*, Vol. 5/9, <https://doi.org/10.1126/sciadv.aax3323>. [13]
- Berestycki, C. et al. (2022), “Measuring and assessing the effects of climate policy uncertainty”, *OECD Economics Department Working Papers*, No. 1724, OECD Publishing, Paris, <https://doi.org/10.1787/34483d83-en>. [67]
- Black, S., K. Zhunussova and I. Parry (2022), “Carbon Taxes or Emissions Trading Systems?”, *Staff Climate Notes*, Vol. 2022/006, p. 1, <https://doi.org/10.5089/9798400212307.066>. [61]
- Borghesi, S., C. Franco and G. Marin (2019), “Outward Foreign Direct Investment Patterns of Italian Firms in the European Union’s Emission Trading Scheme*”, *The Scandinavian Journal of Economics*, Vol. 122/1, pp. 219-256, <https://doi.org/10.1111/sjoe.12323>. [85]
- Branger, F., P. Quirion and J. Chevallier (2017), “Carbon Leakage and Competitiveness of Cement and Steel Industries Under the EU ETS: Much Ado About Nothing”, *The Energy Journal*, Vol. 37/3, <https://doi.org/10.5547/01956574.37.3.fbra>. [87]
- Cabinet of Ministers of Ukraine (2020), “Resolution - On approval of the list of activities, greenhouse gas emissions as a result of which are subject to monitoring, reporting and verification”, <https://zakon.rada.gov.ua/laws/show/880-2020-%D0%BF#Text>. [37]
- Calel, R. and A. Dechezleprêtre (2016), “Environmental Policy and Directed Technological Change: Evidence from the European Carbon Market”, *Review of Economics and Statistics*, Vol. 98/1, pp. 173-191, https://doi.org/10.1162/rest_a_00470. [76]

- Calì, M. et al. (2022), “Too much energy The perverse effect of low fuel prices on firms”, *Journal of Environmental Economics and Management*, Vol. 111, p. 102587, <https://doi.org/10.1016/j.jeem.2021.102587>. [80]
- Carbon Pulse (2024), *Mexico ETS compliance phase delayed into 2024*, <https://carbon-pulse.com/216675/>. [93]
- Clausing, A. and C. Wolfram (2023), “Carbon border adjustments, climate clubs, and subsidy races when climate policies vary”, *Working Paper, Peterson Institute for International Economics*, <https://www.piie.com/sites/default/files/2023-05/wp23-3.pdf>. [63]
- Climate Watch (2022), <https://www.climatewatchdata.org>. [31]
- Council of the European Union (2023), “10875/21 COM (2021) 551; 10902/21 COM (2021) 571”, <https://data.consilium.europa.eu/doc/document/ST-6210-2023-INIT/en/pdf>. [53]
- Dechezleprêtre, A. et al. (2022), “Searching for carbon leaks in multinational companies”, *Journal of Environmental Economics and Management*, Vol. 112, p. 102601, <https://doi.org/10.1016/j.jeem.2021.102601>. [90]
- Dechezleprêtre, A., D. Nachtigall and F. Venmans (2018), “The joint impact of the European Union emissions trading system on carbon emissions and economic performance”, *OECD Economics Department Working Papers*, No. 1515, OECD Publishing, Paris, <https://doi.org/10.1787/4819b016-en>. [73]
- Dechezleprêtre, A. and M. Sato (2017), “The Impacts of Environmental Regulations on Competitiveness”, *Review of Environmental Economics and Policy*, Vol. 11/2, pp. 183-206, <https://doi.org/10.1093/reep/rex013>. [69]
- Douenne, T. and A. Fabre (2020), “French attitudes on climate change, carbon taxation and other climate policies”, *Ecological Economics*, Vol. 169, p. 106496, <https://doi.org/10.1016/j.ecolecon.2019.106496>. [12]
- Dussaux, D. (2020), “The joint effects of energy prices and carbon taxes on environmental and economic performance: Evidence from the French manufacturing sector”, *OECD Environment Working Papers*, No. 154, OECD Publishing, Paris, <https://doi.org/10.1787/b84b1b7d-en>. [77]
- Dussaux, D., F. Vona and A. Dechezleprêtre (2020), “Carbon Offshoring: Evidence from French Manufacturing Companies”, *Sciences Po publications 23/2020*, *Sciences Po*. [91]
- Ellis, J., D. Nachtigall and F. Venmans (2019), “Carbon pricing and competitiveness: Are they at odds?”, *OECD Environment Working Papers*, No. 152, OECD Publishing, Paris, <https://doi.org/10.1787/f79a75ab-en>. [45]
- Environment and Climate Change Canada (2020), “Pan-Canadian Approach to Pricing Carbon Pollution - Interim Report”, https://publications.gc.ca/collections/collection_2021/eccc/En4-423-1-2021-eng.pdf. [57]

- Environment and Climate Change Canada (2020), “Pan-Canadian Approach to Pricing Carbon Pollution - Interim Report 2020”, [20]
https://publications.gc.ca/collections/collection_2021/eccc/En4-423-1-2021-eng.pdf.
- European Commission (2023), “Carbon Border Adjustment Mechanism”, [47]
<https://taxation-customs.ec.europa.eu/system/files/2023-05/20230510%20CBAM%20factsheet.pdf>.
- European Parliament Press Room (2022), “Climate change: Deal on a more ambitious Emissions Trading System (ETS)”, *Press Releases 18-12-2022*, [38]
<https://www.europarl.europa.eu/news/en/press-room/20221212IPR64527/climate-change-deal-on-a-more-ambitious-emissions-trading-system-ets> (accessed on 1 June 2023).
- Flachsland, C. et al. (2018), “Five Myths About a European Union Emissions Trading System Carbon Price Floor”, *Report. Resources for the Future*, [68]
https://media.rff.org/documents/10-18_Rpt_Burtraw_et_al_final.pdf.
- Flues, F. and B. Lutz (2015), “Competitiveness Impacts of the German Electricity Tax”, *OECD Environment Working Papers*, No. 88, OECD Publishing, Paris, [81]
<https://doi.org/10.1787/5js0752mkzmv-en>.
- Flues, F. and K. Van Dender (2017), “Permit allocation rules and investment incentives in emissions trading systems”, *OECD Taxation Working Papers*, No. 33, OECD Publishing, Paris, [15]
<https://doi.org/10.1787/c3acf05e-en>.
- Flues, F. and K. van Dender (2020), “Carbon pricing design: Effectiveness, efficiency and feasibility: An investment perspective”, *OECD Taxation Working Papers*, No. 48, OECD Publishing, Paris, [6]
<https://doi.org/10.1787/91ad6a1e-en>.
- Garsous, G. and T. Kozluk (2017), “Foreign Direct Investment and The Pollution Haven Hypothesis: Evidence from Listed Firms”, *OECD Economics Department Working Papers*, No. 1379, OECD Publishing, Paris, [86]
<https://doi.org/10.1787/1e8c0031-en>.
- Government of Canada (2023), *Carbon pollution pricing systems across Canada*, [27]
<https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work.html> (accessed on 5 June 2023).
- Government of Canada (2023), *The federal carbon pollution pricing benchmark*, [26]
<https://www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/federal-carbon-pollution-pricing-benchmark.html> (accessed on 5 June 2023).
- Government of Canada (2021), *Exploring Border Carbon Adjustments for Canada*, [64]
<https://www.canada.ca/en/department-finance/programs/consultations/2021/border-carbon-adjustments/exploring-border-carbon-adjustments-canada.html> (accessed on 10 June 2023).

- Greenhouse Gas Pollution Pricing Act (2023), *SCHEDULE 4 - (Paragraph 174(3)(b), subsections 174(5), 178(2), 181(3) and section 191) - Excess Emissions Charge*, <https://laws-lois.justice.gc.ca/eng/acts/G-11.55/page-29.html> (accessed on 14 June 2023). [28]
- He Waka Eke Noa (2022), “Initial Assessment of S215 Report”, <https://hewakaekenoa.nz/wp-content/uploads/2022/12/He-Waka-Eke-Noa-initial-assessment-S-215-21-12.pdf>. [42]
- Henderson, B. and M. Verma (2021), “Global assessment of the carbon leakage implications of carbon taxes on agricultural emissions”, *OECD Food, Agriculture and Fisheries Papers*, No. 170, OECD Publishing, Paris, <https://doi.org/10.1787/fc304fad-en>. [43]
- HM Treasury and Department for Energy Security (2023), “Addressing carbon leakage risk to support decarbonisation”, *Open Consultation*, <https://www.gov.uk/government/consultations/addressing-carbon-leakage-risk-to-support-decarbonisation> (accessed on 10 June 2023). [65]
- Hobbie, H., M. Schmidt and D. Möst (2019), “Windfall profits in the power sector during phase III of the EU ETS: Interplay and effects of renewables and carbon prices”, *Journal of Cleaner Production*, Vol. 240, p. 118066, <https://doi.org/10.1016/j.jclepro.2019.118066>. [50]
- Huber, B. (2013), “How Did RGGI Do It? Political Economy and Emissions Auctions”, *Ecology Law Quarterly*, Vol. 40, pp. 59-106, https://scholarship.law.nd.edu/law_faculty_scholarship/473. [16]
- ICAP (2023), *Documentation Allowance Price Explorer*, <https://icapcarbonaction.com/en/documentation-allowance-price-explorer> (accessed on 30 May 2023). [23]
- ICAP (2023), “Emissions Trading Worldwide: Status Report 2023”, *Berlin: International Carbon Action Partnership*, https://icapcarbonaction.com/system/files/document/ICAP%20Emissions%20Trading%20Worldwide%202023%20Status%20Report_0.pdf. [1]
- ICAP (2023), “Emissions Trading Worldwide: Status Report 2023.”, *Berlin: International Carbon Action Partnership*. [19]
- ICAP (2022), “Emissions Trading Worldwide: Status Report 2022.”, *Berlin: International Carbon Action Partnership*, <https://icapcarbonaction.com/en/publications/emissions-trading-worldwide-2022-icap-status-report>. [8]
- ICAP (2022), *EU reaches landmark provisional agreement on ETS reform and new policies to meet 2030 target*, <https://icapcarbonaction.com/en/news/eu-reaches-landmark-provisional-agreement-ets-reform-and-new-policies-meet-2030-target> (accessed on 2 May 2023). [35]
- ICAP (n.d.), *Allocation*, <https://icapcarbonaction.com/en/allocation> (accessed on 1 April 2023). [58]

- IEA (2023), "Extended world energy balances", *IEA World Energy Statistics and Balances* (database), <https://doi.org/10.1787/data-00513-en> (accessed on 28 March 2023). [32]
- IEA (2020), "Implementing Effective Emissions Trading Systems", *IEA, Paris*, License: CC BY 4.0, <https://www.iea.org/reports/implementing-effective-emissions-trading-systems>. [54]
- IETA (2022), "CARBON MARKET BUSINESS BRIEF - ALBERTA", https://ieta.org/resources/Resources/CarbonMarketBusinessBrief/2022/BusinessBrief_Alberta2022.pdf. [22]
- IETA (2022), "CARBON MARKET BUSINESS BRIEF - CANADA FEDERAL OUTPUT-BASED PRICING SYSTEM (OBPS)", https://ieta.org/resources/Resources/CarbonMarketBusinessBrief/2022/BusinessBrief_Canada2022.pdf. [21]
- IPCC (2023), *AR6 Synthesis Report - Headline Statements*, <https://www.ipcc.ch/report/ar6/syr/resources/spm-headline-statements/> (accessed on 6 May 2023). [30]
- Joltreau, E. and K. Sommerfeld (2019), "Why does emissions trading under the EU Emissions Trading System (ETS) not affect firms' competitiveness? Empirical findings from the literature", *Climate Policy*, Vol. 19/4, pp. 453-471, <https://doi.org/10.1080/14693062.2018.1502145>. [56]
- Kallbekken, S., S. Kroll and T. Cherry (2011), "Do you not like Pigou, or do you not understand him? Tax aversion and revenue recycling in the lab", *Journal of Environmental Economics and Management*, Vol. 62/1, pp. 53-64, <https://doi.org/10.1016/j.jeem.2010.10.006>. [14]
- Koch, N. (2016), "European Climate Policy and Industrial Relocation: Evidence from German Multinational Firms", *SSRN Electronic Journal*, <https://doi.org/10.2139/ssrn.2868283>. [84]
- Koch, N. and H. Basse Mama (2019), "Does the EU Emissions Trading System induce investment leakage? Evidence from German multinational firms", *Energy Economics*, Vol. 81, pp. 479-492, <https://doi.org/10.1016/j.eneco.2019.04.018>. [83]
- Kuneman, E. et al. (2022), "Benchmark-based allocation in emissions trading systems: experiences to date and insights on design", *Berlin: ICAP*. [48]
- Löschel, A., B. Lutz and S. Managi (2019), "The impacts of the EU ETS on efficiency and economic performance – An empirical analyses for German manufacturing firms", *Resource and Energy Economics*, Vol. 56, pp. 71-95, <https://doi.org/10.1016/j.reseneeco.2018.03.001>. [75]
- Lutz, B. (2016), "Emissions Trading and Productivity: Firm-Level Evidence from German Manufacturing", *SSRN Electronic Journal*, <https://doi.org/10.2139/ssrn.2850541>. [74]

- Marcantonini, C. et al. (2017), “Free allowance allocation in the EU ETS”, *Energy & Climate. Florence School of Regulation. Robert Schuman Centre for Advanced Studies. European University Institute*. 2, https://cadmus.eui.eu/bitstream/handle/1814/46048/RSCAS_FSR_PB_2017_02.pdf. [52]
- Marten, M. and K. van Dender (2019), “The use of revenues from carbon pricing”, *OECD Taxation Working Papers no. 43*, <https://doi.org/10.1787/22235558>. [11]
- Massachusetts Department of Environmental Protection (2023), *Massachusetts Carbon Allowance Registry Document Repository - An archive of market monitor auction and quarterly reports*, <https://www.mass.gov/lists/massachusetts-carbon-allowance-registry-document-repository> (accessed on 10 June 2023). [29]
- MEMR (2023), *The Minister of Energy and Mineral Resources Launches Carbon Trading in the Power Generation Subsector*, <https://www.esdm.go.id/id/media-center/arsip-berita/menteri-esdm-luncurkan-perdagangan-karbon-subsektor-pembangkit-listrik> (accessed on 6 May 2023). [33]
- Ministry for the Environment and Ministry for Primary Industries (2022), “Pricing agricultural emissions: Consultation document.”, *Wellington: Ministry for the Environment*, <https://environment.govt.nz/assets/publications/Pricing-agricultural-emissions-consultation-document.pdf>. [39]
- Ministry for the Environment and Ministry for Primary Industries (2022), “Pricing agricultural emissions: Report under section 215 of the Climate Change Response Act 2002”, *Wellington: Ministry for the Environment*, <https://environment.govt.nz/assets/publications/Pricing-agricultural-emissions-report-under-section-215-of-the-CCRA.pdf>. [41]
- Mizuho Research & Technologies, Ltd. (2022), *Tokyo Emissions Trading Seminar - Reference Quotations for Transaction Prices in the Tokyo Cap and Trade Program*. [25]
- Naegele, H. and A. Zaklan (2019), “Does the EU ETS cause carbon leakage in European manufacturing?”, *Journal of Environmental Economics and Management*, Vol. 93, pp. 125-147, <https://doi.org/10.1016/j.jeem.2018.11.004>. [78]
- Nordhaus, W. (1994), *Managing the Global Commons*, Cambridge: MIT Press. [4]
- Nova Scotia Cap-and-Trade Program (2023), “Summary Results Report - Auction of Emission Allowances - 14 June 2023”, <https://climatechange.novascotia.ca/sites/default/files/auction-summary-results-report-2023-06-07.pdf>. [24]
- OECD (2023), *Environmental Tax Policy Review of Andalusia*, OECD Publishing, Paris, <https://doi.org/10.1787/fe6d8b45-en>. [44]
- 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>. [40]

- OECD (2021), *Effective Carbon Rates 2021: Pricing Carbon Emissions through Taxes and Emissions Trading*, OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing, Paris, <https://doi.org/10.1787/0e8e24f5-en>. [18]
- OECD (2021), *Policies for a Carbon-Neutral Industry in the Netherlands*, OECD Publishing, Paris, <https://doi.org/10.1787/6813bf38-en>. [9]
- OECD (2020), *Climate Policy Leadership in an Interconnected World: What Role for Border Carbon Adjustments?*, OECD Publishing, Paris, <https://doi.org/10.1787/8008e7f4-en>. [46]
- Official Journal of the European Union (2023), "Legislation - 16 May 2023", Vol. 66, <https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=OJ:L:2023:130:FULL>. [62]
- Otoritas Jasa Keuangan (2023), *Indonesia introduces carbon trading policy to reduce emissions*, <https://www.ojk.go.id/keuanganberkelanjutan/en/newsmedia/detailnews/3039/indonesia-introduces-carbon-trading-policy-to-reduce-emission#:~:text=Officials%20have%20said%20a%20fully,for%20coal-fired%20power%20plants>. (accessed on 10 May 2023). [34]
- Parry, I., S. Black and K. Zhunussova (2022), "Carbon Taxes or Emissions Trading Systems?", *Staff Climate Notes*, Vol. 2022/006, p. 1, <https://doi.org/10.5089/9798400212307.066>. [7]
- Pizer, W. (1997), "Prices vs. Quantities Revisited: The Case of Climate Change", *Resources for the Future*, Vol. Discussion Papers 10498. [5]
- Porter, M. and C. Linde (1995), "Toward a New Conception of the Environment-Competitiveness Relationship", *Journal of Economic Perspectives*, Vol. 9/4, pp. 97-118, <https://doi.org/10.1257/jep.9.4.97>. [70]
- Potomac Economics (2021), "Market Monitor Report for Auction 51 - March 5, 2021", https://www.rggi.org/sites/default/files/Uploads/Auction-Materials/51/Auction_51_Market_Monitor_Report.pdf. [60]
- Quirion, P. (2007), "Comment faut-il distribuer les quotas échangeables de gaz à effet de serre ?", *Revue française d'économie*, Vol. 22/2, pp. 129-164, <https://doi.org/10.3406/rfeco.2007.1651>. [49]
- Rentschler, J. and M. Bazilian (2016), "Reforming fossil fuel subsidies: drivers, barriers and the state of progress", *Climate Policy*, Vol. 17/7, pp. 891-914, <https://doi.org/10.1080/14693062.2016.1169393>. [79]
- Reuters (2023), *Indonesia launches carbon trading mechanism for coal power plants*, <https://www.reuters.com/business/energy/indonesia-launches-carbon-trading-mechanism-coal-power-plants-2023-02-22/> (accessed on 10 May 2023). [36]
- Roberts, M. and M. Spence (1976), "Effluent charges and licenses under uncertainty", *Journal of Environmental Economics and Management*, Vol. 5, pp. 193-208. [3]
- Sato, M. and A. Dechezleprêtre (2015), "Asymmetric industrial energy prices and international trade", *Energy Economics*, Vol. 52, pp. S130-S141, <https://doi.org/10.1016/j.eneco.2015.08.020>. [89]

- Sijm, J. et al. (2008), “The impact of the EU ETS on electricity prices. Final report to DG Environment of the European Commission (No. ECN-E--08-007)”, *Energy research Centre of the Netherlands ECN*. [55]
- Sijm, J., K. Neuhoff and Y. Chen (2006), “CO₂ cost pass-through and windfall profits in the power sector”, *Climate Policy*, Vol. 6/1, pp. 49-72, <https://doi.org/10.1080/14693062.2006.9685588>. [51]
- Skatteministeriet (2022), “A large majority agree on historic CO2 reductions”, *Bredt flertal aftaler historisk CO2-reduktion*, <https://www.skm.dk/aktuelt/presse-nyheder/nyheder/bredt-flertal-aftaler-historisk-co2-reduktion/> (accessed on 10 June 2023). [10]
- Teusch, J. and S. Ribansky (2021), “Greening international aviation post COVID-19: What role for kerosene taxes?”, *OECD Taxation Working Papers*, No. 55, OECD Publishing, Paris, <https://doi.org/10.1787/d0e62c41-en>. [17]
- Van Dender, K. and A. Raj (2022), “Progressing carbon pricing - a Sisyphean task?”, *Gestion & Finances Publiques* 7, pp. 43-57, <https://doi.org/10.3166/gfp.2022.ns.010>. [66]
- Verde, S. (2020), “THE IMPACT OF THE EU EMISSIONS TRADING SYSTEM ON COMPETITIVENESS AND CARBON LEAKAGE: THE ECONOMETRIC EVIDENCE”, *Journal of Economic Surveys*, Vol. 34/2, pp. 320-343, <https://doi.org/10.1111/joes.12356>. [72]
- Vie Publique (2022), , <https://www.vie-publique.fr/fiches/21823-quels-sont-les-grands-principes-budgetaires> (accessed on 5 May 2023). [92]
- Weitzman, M. (1974), “Prices vs. Quantities”, *The Review of Economic Studies*, Vol. 41/4, p. 477, <https://doi.org/10.2307/2296698>. [2]

Annex 3.A. Evidence for carbon pricing-induced carbon leakage and competitiveness losses

The lack of internationally coordinated environmental policies has led to a number of studies examining carbon pricing impacts on competitiveness and carbon leakage. Most evidence points to no or low negative competitiveness impacts (with in some cases positive impacts) and carbon leakage. Evidence varies with the outcome, country or industry considered. In particular, where negative impacts are found, this is generally on EITE firms. However, it is important to note that most of the evidence so far is based on historical data, where permit prices had not reached the close to EUR 100 per tonne of CO₂ levels currently observed for the EU ETS and free allocation was widespread in the systems studied.

Various measures of competitiveness include employment, productivity, output, firm profits, investment location, trade flows, foreign direct investment (FDI) and market share.

In terms of mechanisms underlying the impact of asymmetric environmental policies on competitiveness (and hence carbon leakage), two theories stand out (Dechezleprêtre and Sato, 2017^[69]). The first is the pollution heaven hypothesis, which stipulates that when competing companies only differ in terms of the environmental policy stringency they face, those facing stricter regulation lose competitiveness, since higher regulatory costs can result in higher product prices. This can lead firms in those countries with higher costs to lose market share to their competitors in countries with laxer environmental policies. In the long run, this can result in carbon leakage, through the opening of new production facilities or directing FDI to these countries, hence creating pollution heavens. The second is the Porter hypothesis (Porter and Linde, 1995^[70]), which argues that more stringent environmental policies trigger investment in the development of new cleaner technologies. Part of firms' compliance costs can then be offset by the input savings enabled by these technologies. These technologies can also lead to higher productivity and give them international leadership in clean technologies, which can then increase firms' market share internationally.

Evidence on productivity, employment and innovation

Most empirical studies on the impacts of carbon pricing find that it results in lower emissions with no significant competitiveness impacts (see Arlinghaus (2015^[71]) for evidence on the EU ETS as well as in the US and Canada, Verde (2020^[72]) for evidence on the EU ETS).

Several papers find positive effects of carbon pricing on competitiveness indicators (see Dechezleprêtre, Nachtigall and Venmans (2018^[73]) for evidence on impacts of the EU ETS on firms' revenues and fixed assets in France, the Netherlands and Norway, Lutz (2016^[74]) and Löschel, Lutz and Managi (2019^[75]) for the causal effects of the EU ETS on economic performance of German firms in the manufacturing sector). Positive effects on innovation have been highlighted too – see Calel and Dechezleprêtre (2016^[76]) for evidence that the EU ETS increased low-carbon innovation among regulated firms and Dussaux (2020^[77]) for evidence that energy price changes in the French manufacturing industry led large firms to innovate more and all firms to invest more in end-of-pipe pollution abatement technologies.

Regarding the EU ETS, Joltreau and Sommerfeld (2019^[56]) and Naegele and Zaklan (2019^[78]) present empirical findings that energy and carbon costs in most manufacturing industries represented low shares in their budget or material costs. This might be due to high shares of free allocation.

Evidence focusing on taxes which present no exemptions, also points to no and sometimes positive impacts on competitiveness. Increased fossil fuel prices were found to improve productivity for firms located close to the productivity frontier in Indonesia (Rentschler and Bazilian, 2016^[79]) and for manufacturing firms in Indonesia and Mexico (Cali et al., 2022^[80]) – the latter through the incentives these price increases induced to replace inefficient fuel-powered with more productive electricity-powered capital equipment. Flues and Lutz (2015^[81]) find no impact of the electricity tax on German firms in terms of turnover, exports, value added, investment and employment.

Dussaux (2020^[77]), however, finds that while energy price increases had no impact on French manufacturing industry net employment, this masks heterogeneous effects, in that output and workers were reallocated from energy-intensive firms to energy-efficient firms.

Evidence on FDI, trade and relocation

Evidence for firms participating in the EU ETS shows that on average they increase their asset base at home and with no relocation, with exceptions for subgroups of firms with low capital- or high trade-intensity that show a stronger increase in outward FDI than comparable firms that do not participate in the EU ETS. Aus dem Moore, Großkurth and Themann (2019^[82]) observe that multinational firms whose production facilities are regulated by the EU ETS have on average increased their total asset base more strongly in countries regulated under the EU ETS than outside. Koch and Basse Mama (2019^[83]) arrive at similar findings in terms of outward FDI for all German firms participating in the EU ETS, but do observe outward FDI for a subset of firms with low capital intensity in the EU ETS, in line with Koch (2016^[84]). Borghesi, Franco and Marin (2019^[85]) find that trade-intensive Italian firms participating in the EU ETS increased their sales from foreign affiliates significantly more strongly than firms not participating in the EU ETS. As relocation bears costs as well, production went up their existing subsidiaries abroad rather than through opening new subsidiaries. Garsous and Kozluk (2017^[86]) provide further evidence for the impact of energy prices on FDI on a different set of countries, i.e. 23 OECD countries. They find a significant and positive effect of higher domestic energy prices on firms' outward stock of FDI. However, the effect has a small magnitude.

Regarding import and export effects, the evidence is mixed, with generally low negative impacts (OECD, 2020^[46]). Naegelé and Zaklan (2019^[78]) find no evidence that the EU ETS caused any increase in net import value or embodied carbon emissions. Focusing on two energy-intensive sectors (cement and steel) Branger, Quirion and Chevallier (2017^[87]) find that there was no significant impact of the EU ETS on net import demand. Aldy and Pizer (2015^[88]) find that energy prices negatively impact net imports only for energy-intensive sectors, particularly iron and steel, chemicals, paper, aluminium, cement and bulk glass. Sato and Dechezleprêtre (2015^[89]) find that energy price differences between two trading partners do influence bilateral trade flows. Both papers, however, show effects of small magnitude.

Dechezleprêtre et al. (2022^[90]) use data on multinational firms, which can easily shift production across existing subsidiaries and find no evidence that the EU ETS led to a displacement of carbon emissions from Europe to the rest of the world during the period 2007-2014. Using environmental policy stringency indicators more generally, Dussaux, Vona and Dechezleprêtre (2020^[91]) find evidence for carbon offshoring in French manufacturing, but not due to a pollution heaven motive. Indeed, firms paying higher energy prices do not offshore emissions more than otherwise similar firms. Their results suggest that carbon offshoring resulted from other factors such as trade liberalisation and differences in labour costs between countries.

Notes

¹ The Pilot ETS in Mexico is scheduled to enter its operational phase in 2023.

² E.g. and ETS with a carbon price floor.

³ In the context of ETSs, upstream and downstream regulation have specific meanings. Upstream regulation generally focuses on fuel suppliers whereas downstream regulation generally applies at the point where CO₂ or other GHGs are emitted (e.g. on industrial installations or power plants themselves). Hence, upstream regulation implies that distributors must acquire permits, whereas downstream regulation implies that operators must acquire permits.

⁴ E.g. (Vie Publique, 2022^[92])

⁵ Similar issues are relevant for the international maritime sector.

⁶ Free allocation in other EU ETS sectors is to be phased out starting in 2026.

⁷ Austria, Belgium, Canada, China, Cyprus, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Iceland, Italy, Japan, Kazakhstan, Korea, Latvia, Lithuania, Luxemburg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Slovenia, Spain, Sweden, Switzerland, the United Kingdom, the United States.

⁸ This leaves out Mexico, which implemented the pilot phase of its ETS in 2020, for which there were no auctions and for which the secondary market price was at EUR 0 per tonne of CO₂ in 2021.

⁹ Since 2023, flights to Switzerland have been included as well.

¹⁰ In this report, the stocktake of the evolution of carbon pricing policies for 2023 refers to the first half of 2023 only.

¹¹ This is the case for all Canadian output-based pricing systems, which do not hold auctions and present a fixed, federally mandated, price.

¹² At the time of writing this report, the Mexican Pilot ETS was planned to move to its operational phase in 2023, but this plan has been delay to 2024 (Carbon Pulse, 2024^[93]).

¹³ Only country wide ETSs are presented in this section.

¹⁴ From 33% to 90% if restricting attention to CO₂ emissions from energy use.

¹⁵ Almost 59% if restricting attention to CO₂ emissions from energy use.

¹⁶ Colombia, Indonesia and Ukraine are part of the sample of countries covered by this edition. For lack of information, however, this section does not discuss Colombia.

¹⁷ This start date could be postponed to 2028 in the event gas or oil prices remain too high.

¹⁸ That is, assuming the EU ETS 2 would apply to all currently unpriced emissions in these sectors.

¹⁹ E.g., <https://climatetrace.org/map>, <https://www.transitionzero.org/>, <https://www.unep.org/explore-topics/energy/what-we-do/imeo>.

²⁰ For example, programs such as Overseer^{FM} can help farmers better manage their intrants and get a better grip of their environmental impacts.

²¹ In Massachusetts, the evolution from 75% of free allocation to 0% took place over 3 years, from 2019 to 2021.

²² i.e. overall price divided by the amount of emissions.

²³ However, if benchmarking is based on benchmarks that date back too far in time, changes in production levels and evolution of technologies are not accounted for, and this can result in important overallocation and windfall profits.

²⁴ E.g., Nova Scotia's cap-and-trade website (<https://climatechange.novascotia.ca/cap-trade-regulations#auctions>) has an "Auction Notices and Results" section, or the Massachusetts Department of Environmental Protection presents an archive of market monitor auction and quarterly reports (<https://www.mass.gov/lists/massachusetts-carbon-allowance-registry-document-repository>).

4 Effective carbon tax rates from 2021 to 2023: Latest trends from the road transport sector in OECD and G20 countries

The rise in energy prices in the wake of the Covid-19 pandemic recovery in 2021, exacerbated by Russia's war of aggression against Ukraine in 2022¹ has prompted governments worldwide to provide relief to households and businesses. However, the support measures have raised several concerns, including issues of fairness, fiscal costs, effectiveness in staving off inflation and alignment with climate mitigation objectives. Concerns regarding fairness have arisen as higher income households were more likely to benefit from these measures (see, e.g., Ari et al. (2022^[1])). Furthermore, the incidence of some support measures has also been cause for concern, since tax reductions generally benefit producers more than consumers when fuel supply is inelastic (see, e.g., OECD (2022^[2]), Van Dender and Raj (2022^[3])). Another important concern relates to the impact of support measures on price signals. Given the increasing urgency of climate change mitigation, lowering energy prices and in turn carbon prices signals undermines incentives to fulfil net-zero objectives.

The OECD Energy Support Measures Tracker² is a dataset taking stock of all government interventions to support energy users since February 2021. The vintage of the database used in this report has a cut-off date of 30 January 2023 and covers 41 countries, including all OECD countries except for Hungary, Iceland and Switzerland and three of the remaining G20 economies (Brazil, India and South Africa). At the time of writing, this database is the most comprehensive source of data on energy support measures in OECD economies (see Hemmerlé et al. (2023^[4])).

Most energy support measures can be classified as price or income support measures and may be targeted or broad-based; in the road transport sector, government support mostly consisted in energy price support measures that were not targeted. According to the OECD Energy Support Measures Tracker, out of more than 110 individual measures identified since February 2021, 72% were energy price support measures; 82% were not targeted.³ When they were targeted, most were targeted towards firms in the services sector.

This chapter focuses on fuel excise and carbon tax measures in the road transport sector. The focus is on this sector, because fuel excise and carbon taxes (effective carbon taxes when taken together) in this sector are the most prevalent carbon pricing instruments as compared with other sectors (see e.g., OECD (2019^[5]), Amores et al. (2022^[6]) and Figure 2.4). Hence any change thereof has an important impact on carbon prices. In line with the ECR methodology, rates were gathered for 1 April (or the closest available date) of 2021, 2022 and 2023 for 45 OECD and G20 countries.⁴ They were gathered for cases where the fuel accounted for more than 5% of carbon dioxide (CO₂) emissions in the road transport sector, which implies that the analysis mainly concerns diesel and gasoline.

VAT reductions⁵ and price reductions (e.g. price caps) are not accounted for, and neither are fuel excise or carbon tax cuts which took place between two of the abovementioned dates on a temporary basis.⁶ This includes for instance, the temporary price cap on diesel and gasoline prices introduced by the Hungarian government between November 2021 and July 2022 or VAT tax cuts introduced in Luxembourg. The scope of the analysis is thus consistent with the policy instruments included in the effective carbon rates methodology. Both the OECD Tax Policy Reforms yearly report (OECD, 2023^[7]) and the OECD analysis of the OECD Energy Support Measures Tracker (Hemmerlé et al., 2023^[4]) provide more detail about the measures that are not accounted for in this analysis.

Most of the analysis in this chapter is done in constant 2021 prices as opposed to current prices.⁷ The analysis (see Table 4.1), however, starts by discussing countries according to the direction of change of tax rates on the different types of fuels expressed in *current* terms. There is an interest in considering such figures, as fuel excise and carbon tax rates are typically not indexed on inflation.⁸ In a world with low inflation rates, tracking change in current prices did not have much of an impact on the change in the price signal provided by fuel excise and carbon taxes in a set country. Considering these tax rates in current terms hence enables to consider which carbon pricing policies countries *actively* implemented (in most cases). In the current context, with global inflation at 4.7% in 2021 and 8.8% in 2022 (IMF, 2022^[8]; IMF, 2023^[9]) (and a forecast to 5.9% for G20 countries in 2023 (OECD, 2023^[10])), even though policy might not have evolved yet to include considerations such as inflation, taxes expressed in *constant* terms matter more for behavioural purposes, in particular for the effective price signal provided for decarbonisation incentives. Hence, a major part of the analysis, which presents taxes per tonne of CO₂ (as opposed to units of fuels), is done in constant 2021 prices.

Over 2021 to 2023, in the 45 OECD and G20 countries studied here, tax rates in the road transport sector (for diesel, gasoline, as well as LPG and natural gas in some cases) expressed in current local currency units (LCU) decreased in 15 countries, stagnated in 19 countries and increased in 20 countries. Out of the 19 countries which implemented fuel tax rate increases, seven have provisions for increasing fuel excise rates with inflation (see footnote 8). Between 2022 and 2023, there were no decreases in rates in countries which increased rates in current LCU between 2021 and 2023 – though there may have been between 2021 and 2022. In countries with no change in rates, these stayed constant throughout the period, except in Italy, where the fuel excise rate for diesel was lowered by 40% from 2021 to 2022 before getting back to its 2021 level in 2023. For countries with fuel excise rate decreases over the 2021 to 2023 period, most decreases took place between 2021 and 2022. As a reminder, temporary tax cuts that took place within the span of a year as well as price reductions (price caps), though frequent, are not accounted for here.

Carbon taxes expressed in current LCU were either stable or increased in most countries which had one in 2021, except in Slovenia, which cancelled its carbon tax in 2023. In the thirteen other countries with carbon taxes even when the fuel excise tax decreased, carbon taxes did not. This is the case for Ireland, Mexico, Norway and Sweden. Political economy constraints linked to the increase of carbon taxation might be part of the rationale behind the decoupling of these changes. Carbon taxation being a direct carbon pricing instrument as opposed to a fuel excise tax, which is first and foremost an energy tax⁹, may also help explain this observation: while governments might have decreased fuel excise taxes to help households and businesses cope with the current energy crisis, their aim may not have been to mute carbon price signals.

In the sample analysed in this chapter, tax cuts took place predominantly in Europe and Central Asia – where the energy crisis was possibly the most directly exacerbated by the war in Ukraine. Amongst the 45 OECD and G20 countries, 12 out of the 28 countries in Europe and Central Asia, two out of seven of the countries in East and South Asia and Pacific and one out of six countries from Latin America and the Caribbean implemented at least one fuel excise tax cut between 2021 and 2023.

Increases or decreases in fuel excise and carbon tax rates expressed in current LCU did not particularly apply more to diesel or gasoline. There were two more increases in fuel excise rates on gasoline than on

diesel and two more decreases in rates on diesel than on gasoline. In terms of rate per tonne of CO₂, the “diesel discount” (Harding, 2014^[11]; OECD, 2019^[5]) became more pronounced in about a third of countries, remained the same in another third and improved in the remaining third.

Table 4.1. Tax rate changes in current LCU in the road transport sector between 2021 and 2023

44 OECD and G20 countries

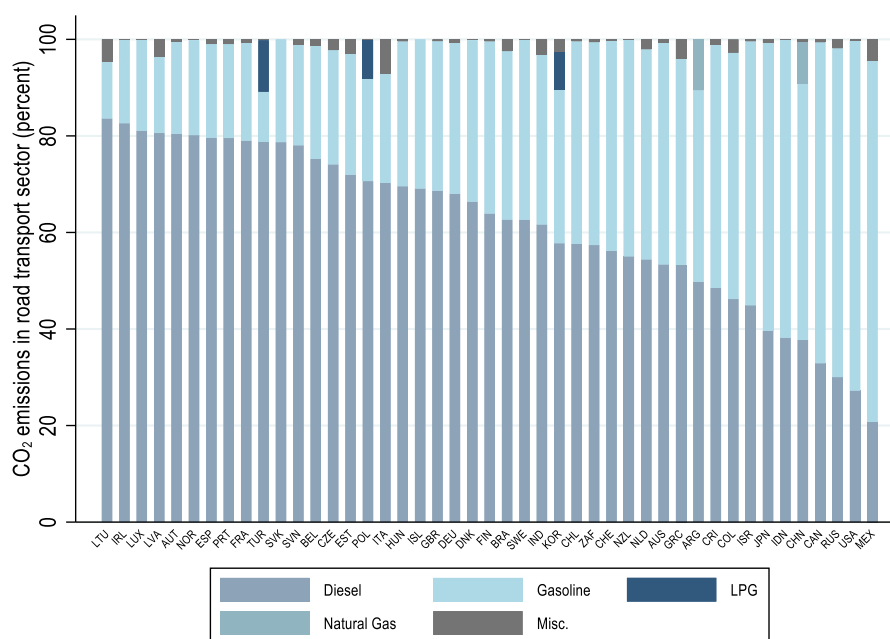
Countries are indicated in bold when tax rate changes did not go in the same direction for all fuels

		Tax rate decrease	Tax rate stagnation	Tax rate increase
Fuel excise	Diesel	Czechia, France (buses and coaches), India, Ireland, Korea, Mexico , Netherlands, Norway, Portugal, Slovenia, Sweden, Switzerland, United Kingdom (13)	Austria, Brazil, Canada*, China, Germany, Estonia, Greece, Italy , Japan, Lithuania, Luxembourg , Latvia, Slovak Republic, Spain, Türkiye, United States (16)	Argentina, Australia, Belgium, Chile, Colombia, Costa Rica, Denmark, Finland, France (propellant, heavy good vehicles), Hungary, Indonesia, Iceland, Israel, New Zealand, Poland, South Africa (17)
	Gasoline	Hungary, India, Ireland, Israel, Korea, Netherlands, Norway, Portugal, Slovenia, Sweden, Switzerland, United Kingdom (12)	Austria, Brazil, Canada, China, Czechia , Germany, Estonia, Finland , Greece, Japan, Lithuania, Latvia, Slovak Republic, Spain, Türkiye, United States (16)	Argentina, Australia, Belgium (unleaded gasoline), Chile, Colombia, Costa Rica, Denmark, France , Indonesia, Iceland, Italy , Luxembourg , Mexico , New Zealand, Poland, South Africa (17)
	LPG	Korea	Lithuania, Türkiye	Poland
	Natural gas			Argentina
Carbon tax	Diesel	Slovenia	Finland, France, Japan, Portugal (non-commercial, road)	Argentina, Colombia, Denmark, Ireland, Iceland, Luxembourg, Mexico, Norway, Portugal (commercial, road), Sweden, South Africa
	Gasoline	Slovenia	Finland, France, Japan, Portugal	Argentina, Colombia, Denmark, Ireland, Iceland, Luxembourg, Mexico, Norway, Sweden, South Africa

Note: The rates considered for the purpose of this table are those that apply to fuels which account for more than 5% of a country's road transport CO₂ emissions as of 1 April 2021. Hence, not all fuel excise and carbon taxes are considered here. Carbon taxes which apply to natural gas or LPG in the road transport sector do exist (in Canada, Denmark, Finland, France, Ireland, Japan, Luxembourg, Mexico, Norway, Portugal, Slovenia, Sweden, South Africa), but not in countries where these fuels account for more than 5% of their road transport CO₂ emissions. Moreover, the rates considered in this table are the rates that apply at the federal level: state- or province-specific rates for the Canada, Mexico or the United States.

* Note that carbon taxes in provinces and territories that either have their own schemes (e.g. British Columbia, New Brunswick) or are subject to the federal carbon pricing system (such as Alberta, Manitoba) that includes the regulatory charge on fossil fuels, did increase from CAD 40 in 2021, to CAD 50 in 2022 and CAD 65 per tonne of CO₂ in 2023 in most cases.

Tax rate decreases did not necessarily take place on the CO₂ bases that were relatively higher in a country, nor did they necessarily increase on bases that were lower (see Table 4.1 and Figure 4.1). Czechia decreased their fuel excise rate on the fuel with the most important share of emissions in the country's road transport sector (above 70%), diesel, while Luxembourg and Italy increased their fuel excise rates on gasoline, which represents less than 20% of these countries' road transport sector CO₂ emissions. Current rates increased or remained stable for road transport sector use of fuels such as LPG and natural gas, which are less important in this sector.

Figure 4.1. Share of fuels in CO₂ emissions in the road transport sector

Note: The category Misc. groups fuels that each make up less than 5% of the country's road transport sector CO₂ emissions.

StatLink  <https://stat.link/yoe5kx>

Rates per unit of fuel may be converted into rates per tonne of CO₂. The tax base of fuel excise and carbon taxes in the road transport sector of the 45 OECD and G20 countries analysed in this chapter is expressed in litres of fuel for liquid fuels such as diesel, gasoline and LPG and cubic metres for gaseous fuels such as natural gas. Using a unit of fuel's carbon content, these taxes can then be expressed in tonne per CO₂ (see Table 4.2). Depending on a fuel's carbon content, the same price per litre of fuel may translate into different prices per tonne of CO₂. For instance, given the carbon content of one litre of LPG is lower than that of diesel, the same tax rate per litre on these two fuels translates into a higher tax per tonne of CO₂ for LPG.

Table 4.2. From tax rates per common commercial units to tax rates per tonne of CO₂

Fuel	Rate per common commercial unit	Equivalent rate in EUR per tonne of CO ₂
Diesel	10 eurocent/L	37.5
Gasoline	10 eurocent/L	43.7
LPG	10 eurocent/L	63.2
Natural gas	10 eurocent/m ³	58.5

Note: OECD calculations based on IEA (IEA, 2023^[12]), *World Energy Statistics and Balances*. The values shown are based on average carbon content of these energy categories across the 44 countries covered in the 2018 *Taxing Energy Use* edition. Actual carbon emissions associated with combusting the respective fuel may vary depending on local fuel characteristics.

Source: Adapted from Table 3.1 of OECD (2019^[5]).

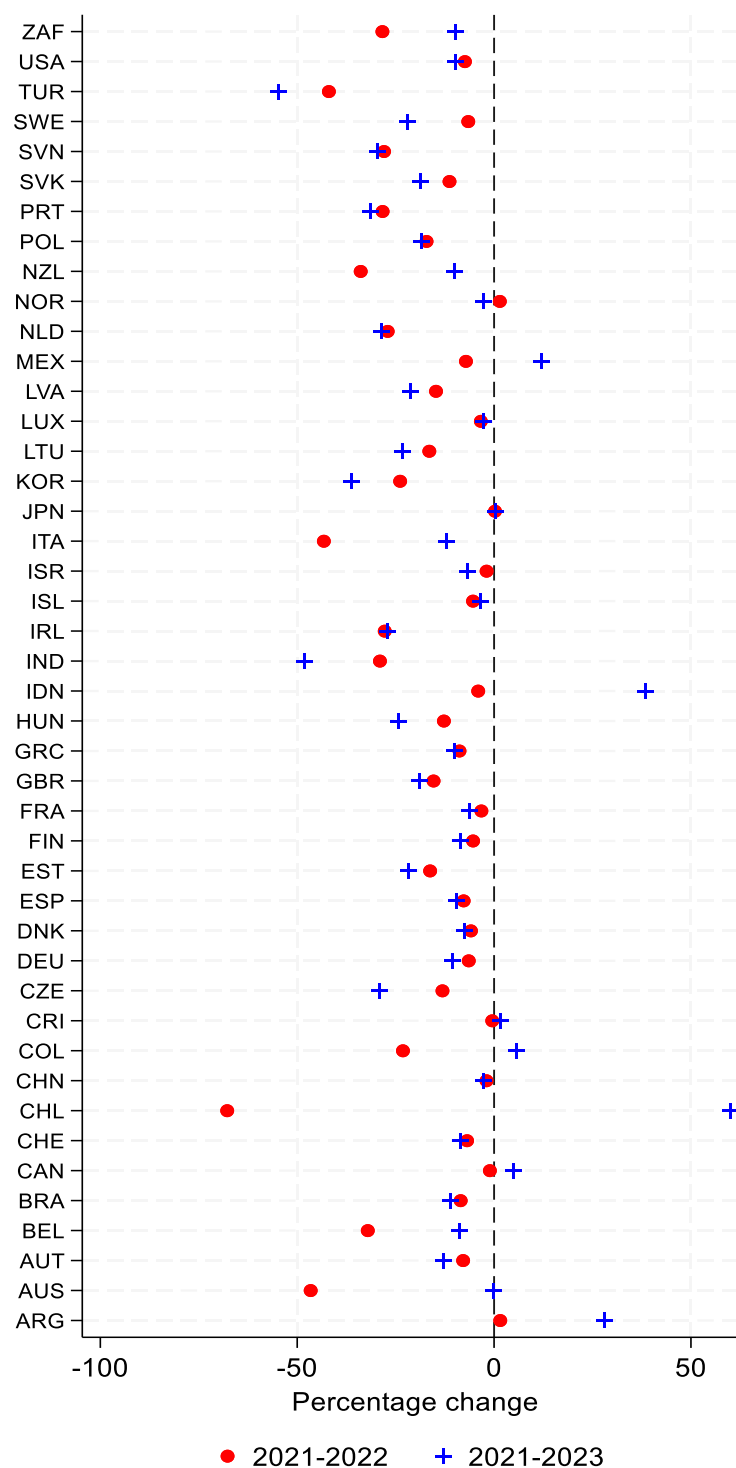
The remainder of the chapter considers rates expressed per tonne of CO₂ in constant 2021 prices and when considering the resulting effective carbon tax rates, most countries have seen a decrease in these

rates (see Figure 4.2). Given that rates expressed per tonne of CO₂ give a sense of the carbon price signal in the road transport sector, comparing them across years is best done by considering constant terms, i.e., accounting for inflation. When expressed in constant 2021 LCU per tonne of CO₂, effective carbon tax rates have decreased in 37 out of 45 countries' road transport sectors from 2021 to 2023. Part of this decrease is due to active policy choices of lowering current fuel excise rates on diesel and gasoline in certain countries (Table 4.1) and part of it is due to inflation combined either with government inaction in reforming fuel excise rates or with an increase in rates that did not match inflation. This contributes to explaining the discrepancy between Figure 4.2 and Table 4.1.¹⁰

Effective carbon tax rates expressed in constant 2021 LCUs increased in 16 countries between 2022 and 2023 as compared to three countries between 2021 and 2022. This resulted in an increase in effective carbon tax rates for eight countries between 2021 and 2023 (Figure 4.2). In Japan, effective carbon tax rates increased very slightly. Indeed, in Japan, tax rates did not vary (Table 4.1) over the whole period, and it is the only country in the sample which has not undergone inflation over 2021 to 2023. Argentina, Chile and Colombia are the only three countries which had provisions for indexing fuel excise or carbon taxes on inflation that also experienced an increase in effective carbon tax rates between 2021 and 2023. While federal fuel excise taxes remained constant in current prices in Canada, carbon taxes in provinces and territories that either have their own schemes or are subject to the federal carbon pricing system, increased, in most cases, by more than 50% in current prices, which translated into an increase in constant prices as well. Given that gasoline holds a more important share of emissions in the Mexican road transport sector, the increase in fuel excise rates on gasoline along with the increase in its carbon tax rates more than compensated the decrease in fuel excise rates on diesel. This resulted in an increase in Mexico's effective carbon tax rates between 2021 and 2023. Finally, Indonesia's fuel excise rates increased enough in current terms to translate into an increase in constant 2021 LCUs. Belgium, Ireland, Italy and Luxembourg are the only EU countries for which rates started increasing again from 2022 onwards.

Figure 4.2. Evolution of effective carbon tax rates in the road transport sector since 2021

Percentage changes between 2021 and 2022 as well as between 2021 and 2023, in constant 2021 LCU



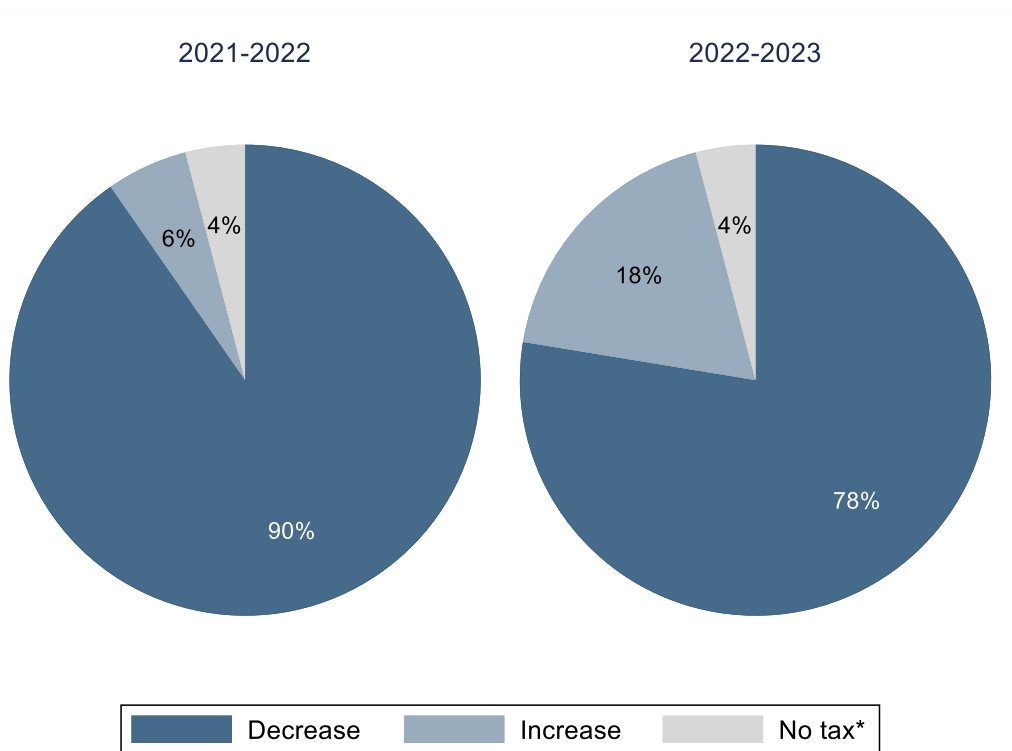
Note: State and province-specific tax rates for Canada, Mexico and the United States are included in the calculations. It is assumed that fuel excise state-level tax rates followed the same trend as federal-level tax rates in the United States and Canada (i.e. did not change in current terms), as well as in Mexico for state-level carbon tax rates.

StatLink  <https://stat.link/s9q8ml>

Despite higher inflation in 2022 than in 2021, most tax rate decreases in the road transport sector took place between 2021 and 2022 – in 2023, rates are already starting to recover (Figure 4.3). A larger share of CO₂ emissions in the 45 countries' road transport sectors underwent a decrease in carbon prices resulting from taxes from 2021 to 2022 than from 2022 to 2023. As observed in current units already, more active policy reforms took place from 2021 to 2022 to decrease rates than from 2022 to 2023. Moreover, even though effective carbon tax rates decreased in most countries between 2021 and 2023, Figure 4.2 shows that even in constant 2021 prices, some increases in carbon rates took place between 2022 and 2023. Even though tax rates in constant 2021 EUR decreased in 2022 and 2023, the median remained stable (about EUR 63.5/tCO₂ in 2021 and 2023, about EUR 62/tCO₂ in 2022) (Figure 4.4). However, the highest rates decreased: while 29% of CO₂ emissions were subject to rates of EUR 120/tCO₂ or higher in 2021, only 21% are subject to such rates in 2023. This is consistent with most decreases taking place in the EU, where fuel excise taxes were highest in 2021.

Figure 4.3. Share of CO₂ emissions from energy use in the road transport sector which underwent a decrease or an increase in taxes

In constant 2021 LCU, 45 OECD and G20 countries

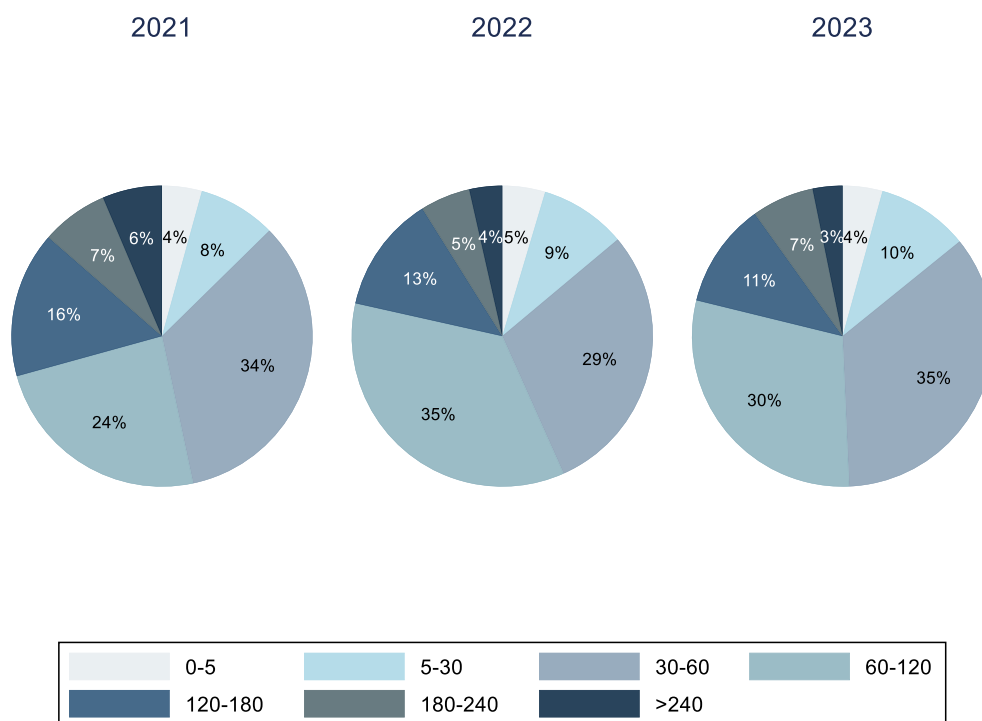


Note: *No tax stands for the emissions that did not face any carbon tax rate in 2021, 2022 and 2023. These are the only tax rates that remained the same over the whole period when taken in constant 2021 LCU.

StatLink  <https://stat.link/tumckd>

Figure 4.4. Share of CO₂ emissions in the road transport sector subject to different tax rate levels

In EUR 2021, 45 OECD and G20 countries



Note: Rates were converted into (constant) 2021 EUR using the latest available OECD exchange rate and inflation data.

StatLink  <https://stat.link/uixbz4>

While effective carbon tax rates did decrease in a large majority of OECD and G20 countries between 2021 and 2023, they have already started to recover. However, the reality of a low-inflation economy may be changing and indexing fuel excise and carbon tax rates on inflation may be a way to maintain carbon price signals provided by taxes as well as to raise revenue in line with increasing costs.

The decrease in effective carbon tax rates in the road transport sector between 2021 and 2023 in all EU countries and the increase in permit prices (even in constant 2021 rates, see Chapter 3) for sectors subject to the EU emissions trading system (ETS) has contributed to lessening the gap between ECRs in these different sectors. Indeed, between 2021 and 2023, in OECD and G20 countries covered by an ETS, average ECRs in the road transport sector have decreased by 7.5% (from about EUR 97 to EUR 90 per tonne of CO₂) and have increased by 46% in the electricity sector (from about EUR 9 to EUR 14 per tonne of CO₂) and by 26% in the industry sector (from about EUR 7 to EUR 9 per tonne of CO₂). An EU ETS 2 with auctioned permit prices, may contribute in the future to avoiding the decreases observed in sectors mainly covered by taxes such as the road transport sector. However, the recent plummeting of permit price levels in Korea shows that ETSs do not necessarily constitute a stronghold against economic downturns.

References

- Amores A. F., M. (2022), *Taxing Households Energy Consumption in the EU: the Tax Burden and its Redistributive effect*, JRC130358. [6]
- Ari, A. et al. (2022), “Surging Energy Prices in Europe in the Aftermath of the War: How to Support the Vulnerable and Speed up the Transition Away from Fossil Fuels”, *IMF Working Paper*, 22/152. [1]
- Boone, L. and A. Elgouacem (2021), *At the cross-roads of a low-carbon transition: what can we learn from the current energy crisis?*, <https://oecdecoscope.blog/2021/10/22/at-the-cross-roads-of-a-low-carbon-transition-what-can-we-learn-from-the-current-energy-crisis/>. [14]
- Harding, M. (2014), “The Diesel Differential: Differences in the Tax Treatment of Gasoline and Diesel for Road Use”, *OECD Taxation Working Papers*, No. 21, OECD Publishing, Paris, <https://doi.org/10.1787/5jz14cd7hk6b-en>. [11]
- Hemmerlé, Y. et al. (2023), “Aiming better: Government support for households and firms during the energy crisis”, *OECD Economic Policy Papers*, No. 32, OECD Publishing, Paris, <https://doi.org/10.1787/839e3ae1-en>. [4]
- IEA (2023), “Extended world energy balances”, *IEA World Energy Statistics and Balances* (database), <https://doi.org/10.1787/data-00513-en> (accessed on 24 November 2023). [12]
- IEA (2021), “What is behind soaring energy prices and what happens next?”, <https://www.iea.org/commentaries/what-is-behind-soaring-energy-prices-and-what-happensnext>. [13]
- IMF (2023), “World Economic Outlook Update: Inflation Peaking amid Low Growth”, *Washington, DC. January*. [9]
- IMF (2022), “World Economic Outlook: Countering the Cost-of-Living Crisis”, *Washington, DC. October*. [8]
- OECD (2023), *OECD Economic Outlook, Interim Report March 2023: A Fragile Recovery*, OECD Publishing, Paris, <https://doi.org/10.1787/d14d49eb-en>. [10]
- OECD (2023), *Tax Policy Reforms 2023: OECD and Selected Partner Economies*, OECD Publishing, Paris, <https://doi.org/10.1787/d8bc45d9-en>. [7]
- OECD (2022), “Why governments should target support amidst high energy prices”, <https://www.oecd.org/ukraine-hub/policy-responses/why-governments-should-target-supportamidst-high-energy-prices-40f44f78/>. [2]
- OECD (2019), *Taxing Energy Use 2019: Using Taxes for Climate Action*, OECD Publishing, Paris, <https://doi.org/10.1787/058ca239-en>. [5]
- Van Dender, K. and A. Raj (2022), “Progressing carbon pricing - a Sisyphean task?”, *Gestion & Finances Publiques* 7, pp. 43-57, <https://doi.org/10.3166/gfp.2022.ns.010>. [3]

Notes

¹ Long term trends such as underinvestment in natural gas and clean energy supply are also at play (see IEA (2021^[13])).

² <https://bit.ly/3P2E47B>.

³ Indeed, in times of crisis, broad-base tax reductions are easier to administer – especially when no prior targeting system is in place in the country. This also has the advantage of reaching those that may not be captured by the existing social benefits system. However, this comes at the expense of maintaining a price signal that is commensurate with the supply shortages and that is aligned with a net-zero pathway (see, e.g. Boone and Elgouacem (2021^[14]), OECD (2022^[2])).

⁴ All OECD and G20 countries as of January 2023, excluding Saudi Arabia.

⁵ Chapter 1 provides an explanation of instruments covered by the ECR indicator and the rationale for leaving some pricing instruments out of the database.

⁶ Indeed, in stable times, while permit prices are volatile within a year, fuel excise and carbon taxes are generally fixed throughout a year. Hence, ECRs generally account for taxes as available on 1 April and average permit prices over the year.

⁷ Current prices in a given year in a given currency are expressed in the value of the currency for that year. Hence, when comparing current prices over time, price inflation is not accounted for. Constant prices adjust for price inflation and are expressed against a benchmark year. They may then be used to measure “true variations” in a series of prices.

⁸ In 2021, Argentina, Australia, Belgium, Colombia, Chile, Denmark, the Netherlands (suspended in 2022), the United Kingdom and South Africa (suspended in 2022) were the only countries among the countries analysed in this chapter which had provisions for indexing such taxes on inflation.

⁹ (That can be translated into a carbon price).

¹⁰ Different tax rate cuts and increases on diesel and gasoline within a same country, along with different carbon contents of these fuels can also contribute to the differences observed.

Annex A. Results including CO₂ emissions from biofuel combustion

This Annex presents Effective Carbon Rates (ECRs) results from Chapter 2, as well as ETS country and sectoral coverage (see Chapter 3) when accounting for CO₂ emissions from biofuel combustion. These emissions represent a non-negligible share of CO₂ emissions from energy use (about 13.5%, see Figure A A.4, Panel A). CO₂ emissions from biofuel combustion face low price coverage and levels. Accordingly, when accounting for CO₂ emissions from biofuel combustion, 38% of total GHG emissions are priced (Figure A A.1). Coverage decreases in all six sectors responsible for CO₂ emissions from energy use, and mostly so in the buildings sector, where the share of emissions facing no carbon price goes from 64% when excluding these emissions, to 81% when including them (Figure A A.2). When accounting for emissions from biofuels, the shares of buildings in total GHG emissions goes up from 6.3% to 10.7%. ECRs in this sector are much lower, as fuel excise taxes often exempt or present lower rates on biofuels (biofuels face the second lowest average ECR after coal, see Figure A A.4, Panel A), especially when used for residential and commercial purposes. ECRs in the industry sector are lower as well, since prices in that sector most stem from emissions trading systems (ETS), which generally do not apply to CO₂ emissions from biofuel combustion (except for the German nEHS, which covers biofuels which do not follow certain sustainability criteria) (Figure A A.3). This also explains why ETS coverage is lower in all countries and sectors when accounting for CO₂ emissions from biofuel combustion (Figure A A.5, Figure A A.6). This is especially the case for the buildings and industry sector, which is where biofuels are most used (Figure A A.4, Panel B).

Figure A A.1. Distribution of ECRs, including CO₂ emissions from biofuel combustion

2021, 72 countries

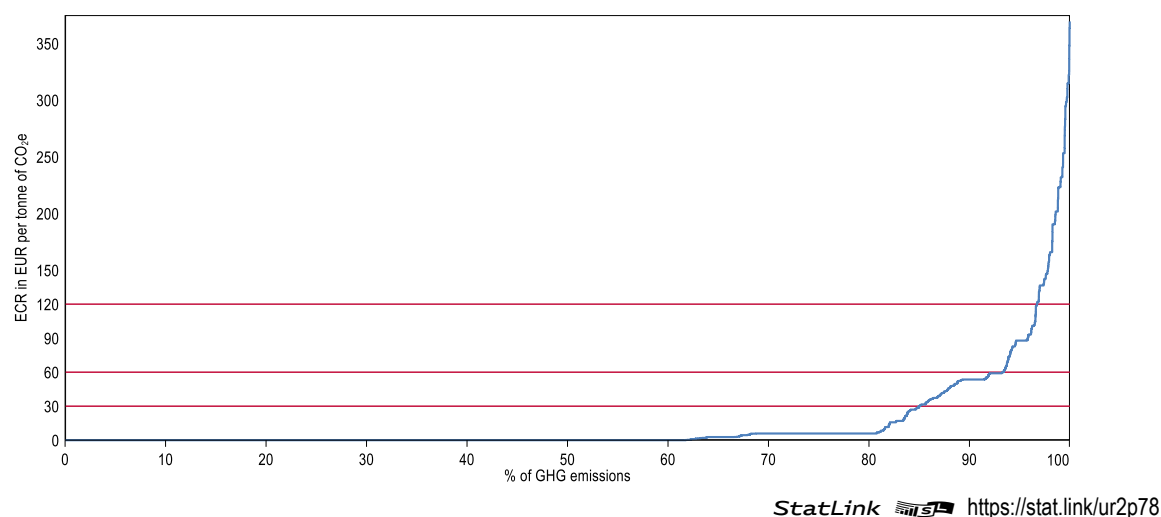
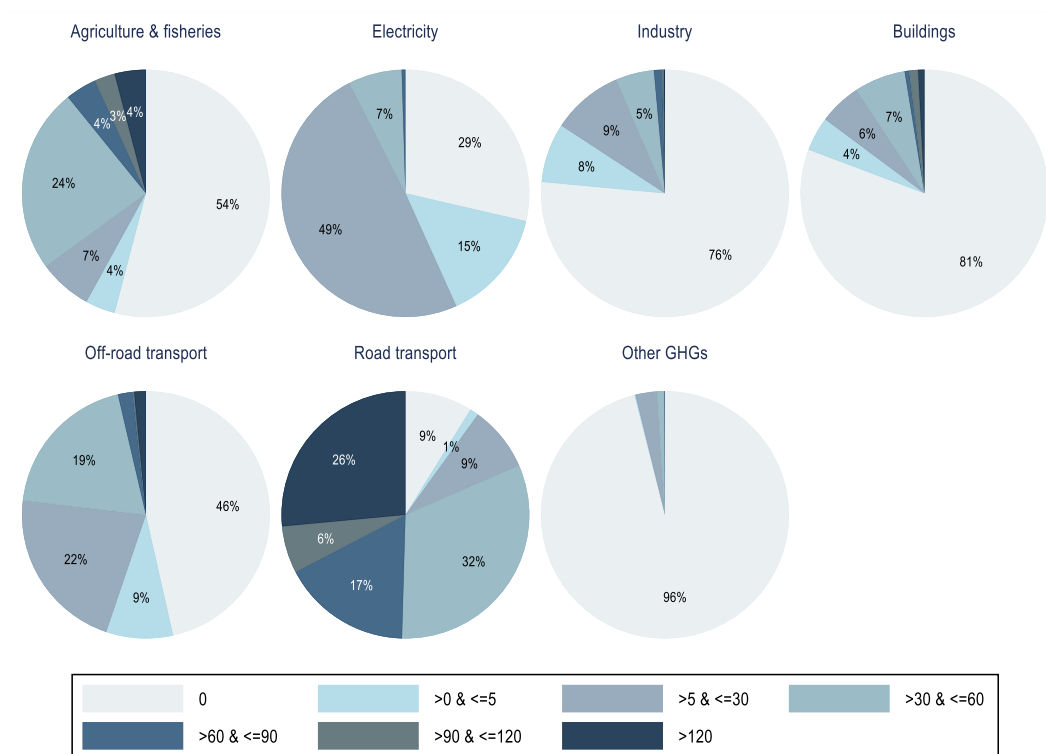


Figure A A.2. Proportion of CO₂e emissions priced at different ECR levels by sector, including CO₂ emissions from biofuel combustion

2021, 72 countries

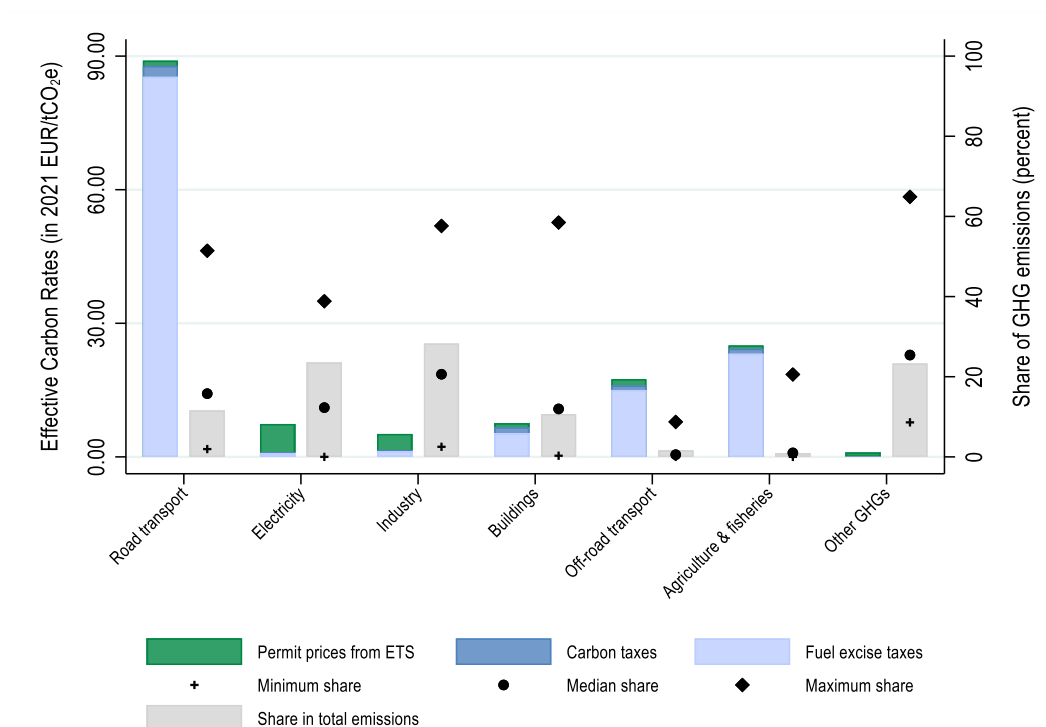


Note: Other GHG emissions refer to emissions from methane (CH₄), nitrous oxide (N₂O), F-gases and process CO₂ emissions excluding LUCF.

StatLink  <https://stat.link/4uxglw>

Figure A A.3. Carbon pricing instruments and share of GHG emissions by sector, including CO₂ emissions from biofuel combustion

2021, 72 countries

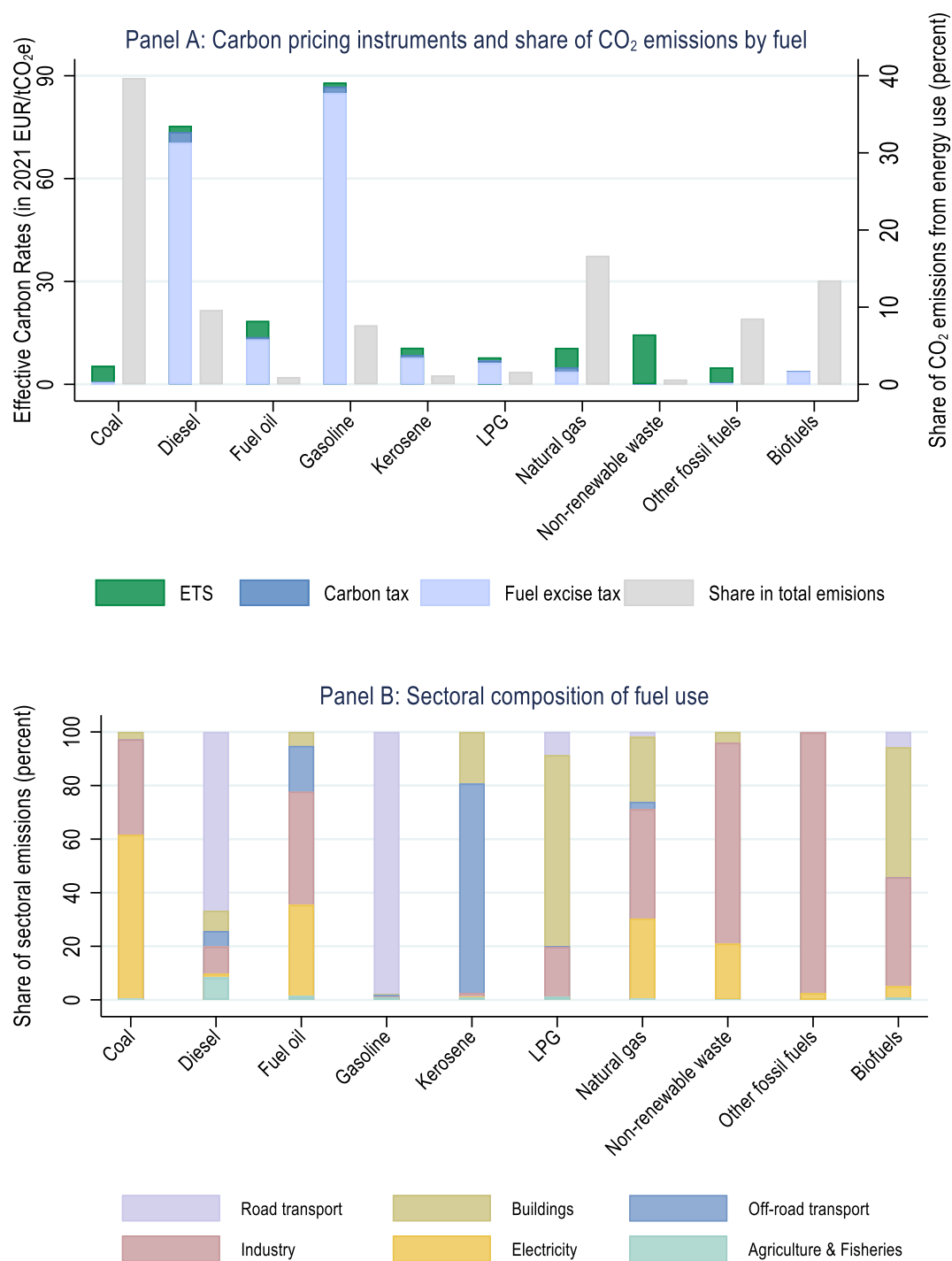


Note: The left-hand side bars of this graph show ECR components by sector. Together, emissions from the road transport, electricity, industry, buildings, off-road transport and agriculture and fisheries sectors make up CO₂ emissions from energy use. Other GHG emissions cover CH₄, N₂O and F-gas emissions as well as CO₂ emissions from industrial process. The right-hand side axis presents shares of emissions from these sectors in total emissions, as well as their country-level variation. “Minimum share” (resp. “Maximum share”) indicates the minimum share this sector may represent in a country’s total GHG emissions. “Median share” is the median of such shares across countries. For instance, the median share in the road transport sector indicates that half of countries in the sample have a road transport sector that accounts for more than 17.5% of national GHG emissions. Other GHG emissions data are from Climate Analysis Indicators Tool (Climate Watch, <https://www.climatewatchdata.org>) while the data on CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[1]).

StatLink  <https://stat.link/vlgxme>

Figure A A.4. ECR levels by fuel and sectoral composition of fuel emissions, including CO₂ emissions from biofuel combustion

2021, 72 countries

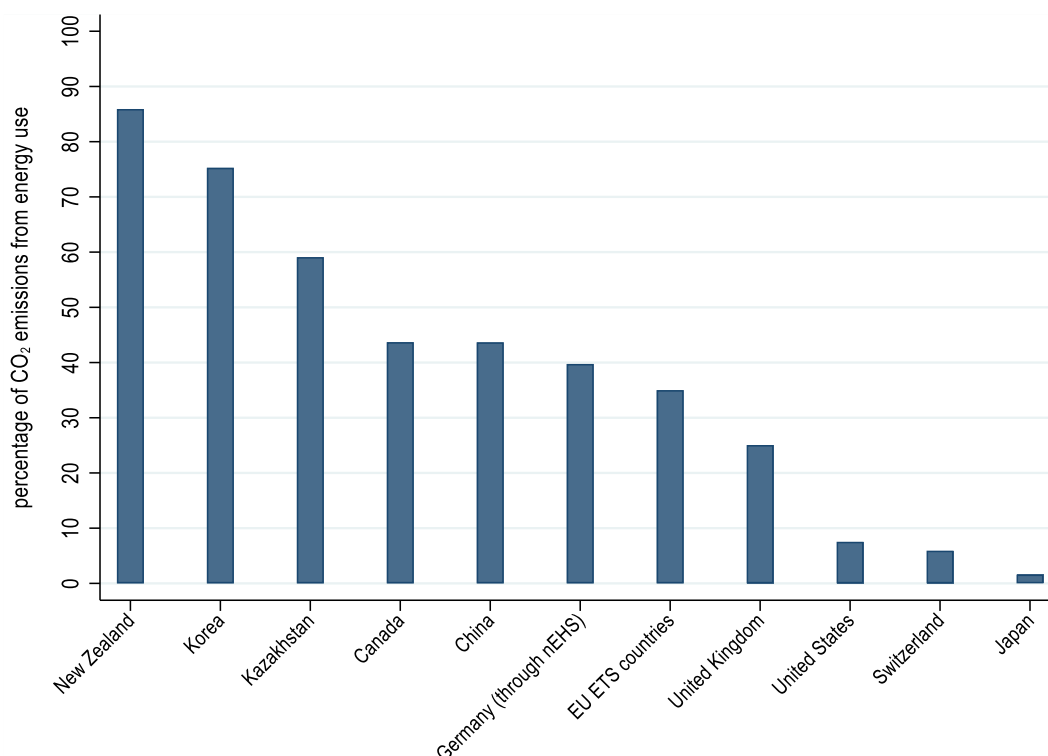


Note: "Coal" stands for "Coal and other solid fossil fuels". Other greenhouse gases are not included here as they are not fuel-based. CO₂ emissions from energy use are based on the IEA World Energy Balances (IEA, 2023^[1]).

StatLink  <https://stat.link/2jt8kq>

Figure A A.5. Shares of CO₂ emissions from energy use priced by ETSs, including CO₂ emissions from biofuel combustion

In countries or supranational jurisdictions that have an ETS with positive permit prices, 2021

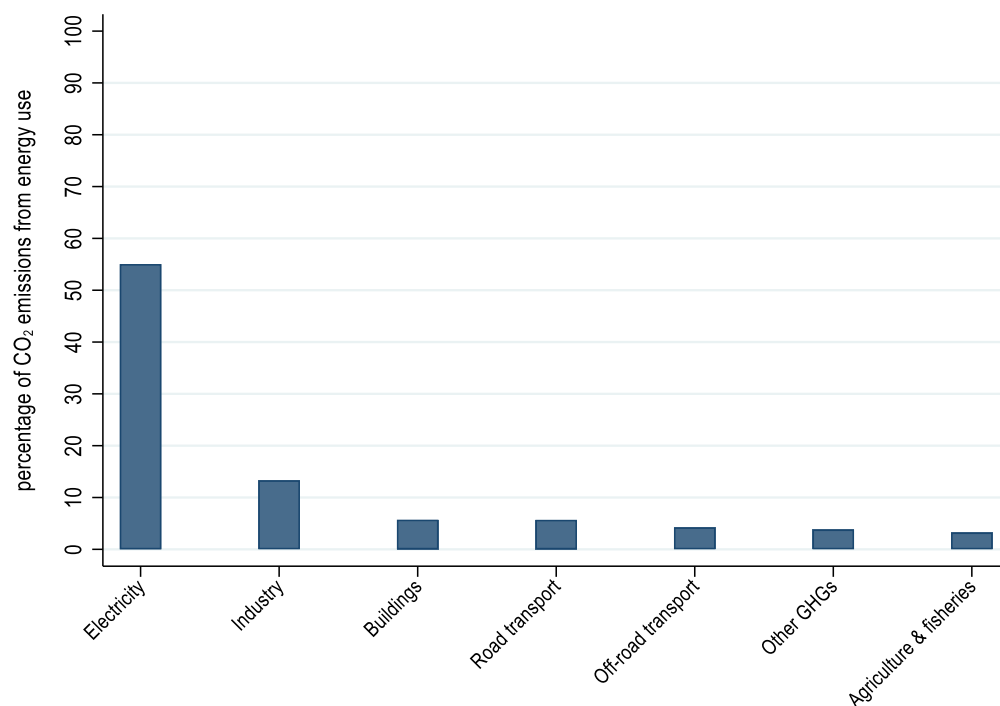


Note: The share presented for Germany separately from the rest of EU ETS countries refers to the share of CO₂ emissions from energy use covered by its national ETS (nationaler Emissionshandelssystem, or nEHS). The share presented for EU ETS countries is the total share over all EU ETS countries covered in this report. The EU ETS applies to all EU countries as well as Iceland, Liechtenstein and Norway. The ECR database in this report does not cover Bulgaria, Croatia, Liechtenstein, Malta and Romania. Mexico's pilot ETS is not presented here because prices were null in 2021. Canada, China, Japan and the United States each have sub-national ETSs, and the country-level share of emissions covered by these systems (along with the national ETS for China) are presented here.

StatLink  <https://stat.link/1k7ctr>

Figure A A.6. Share of sectoral total emissions covered by an ETS, including CO₂ emissions from biofuel combustion

By sector, 2021, 72 countries



Note: The ETSs considered for the calculations presented in this figure are those present in Table 3.2 (33 ETSs). Description of emission trading systems and country-specific methodology.

StatLink  <https://stat.link/1vynpa>

References

IEA (2023), “Extended world energy balances”, *IEA World Energy Statistics and Balances* (database), <https://doi.org/10.1787/data-00513-en> (accessed on 24 November 2023).

[1]

OECD Series on Carbon Pricing and Energy Taxation

Effective Carbon Rates 2023

PRICING GREENHOUSE GAS EMISSIONS THROUGH TAXES AND EMISSIONS TRADING

Successfully transitioning to net-zero greenhouse gas (GHG) emissions requires effective mitigation policy packages, which include carbon pricing measures: a cost-effective policy instrument that not only reduces emissions but also generates revenue to support the transition. This fourth edition of Effective Carbon Rates provides an overview of the carbon pricing landscape, examining fuel excise taxes, carbon taxes, and emissions trading systems (ETSs) through 2021, with updates on developments until 2023. The policy mechanisms examined directly impact the cost of emitting GHGs, influencing shifts in production, consumption, and investment towards low- or zero-carbon options. The analysis covers 72 countries which together account for approximately 80% of global GHG emissions. The report focuses on developments in ETSs and transport fuel taxes amidst the energy crisis and provides comprehensive and comparable data on the current status of GHG emissions pricing that can assist policymakers in identifying priorities and refining carbon mitigation strategies.



PRINT ISBN 978-92-64-42935-2
PDF ISBN 978-92-64-90153-7



9 789264 429352