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 (CO_2) 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 CO_2 emissions from energy use

	Coverage		Marginal explicit carbon rate (in constant 2021 EUR/tCO_2)	
Instrument	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 instruments[2] 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 $MtCO_2e$ 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

ETSs 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 ETSs 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 ETSs 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 ETSs 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 CO_2 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 CO_2 emissions is lower, as is the average rate paid per tonne of CO_2 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 CO_2 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[1]).[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 CO_2 emissions from energy use) and ETS coverage stagnating at 48% of CO_2 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.

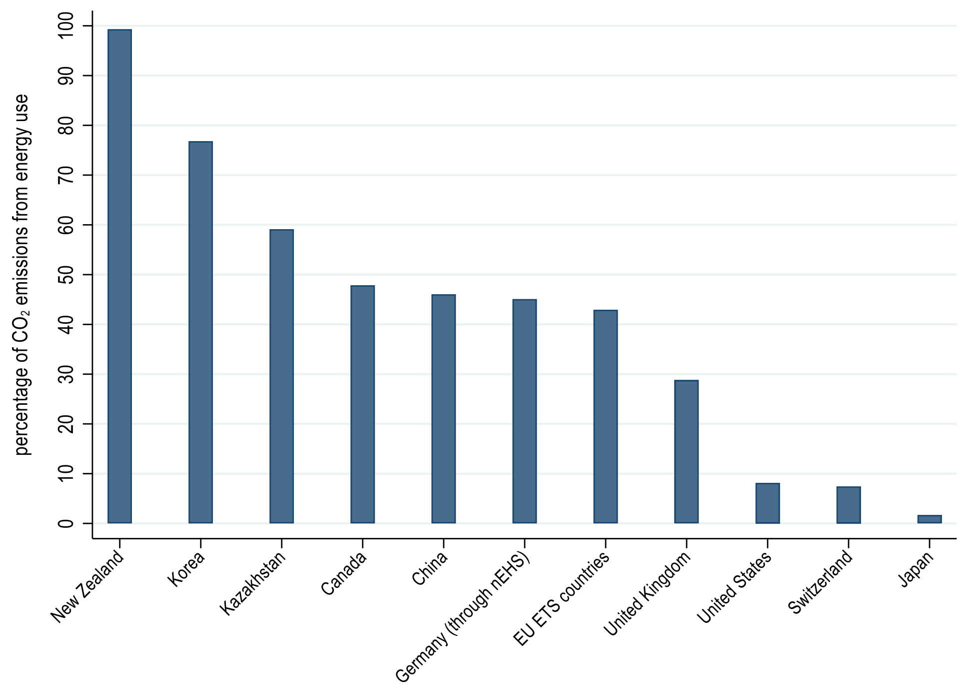
3.2. Emission trading systems in 2021

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 countries[7] of this edition's sample had an ETS with positive permit prices[8] in 2021. Their emissions account for 66% of the sample's GHG emissions.

As compared to 2018, ETS coverage of CO_2 emissions substantially increased in 2021, in China and in Germany. In these two countries, the shares of ETS coverage of CO_2 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 CO_2 emissions from energy use. In 2021, the share of CO_2 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 CO_2 emissions from energy use priced by ETSs

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



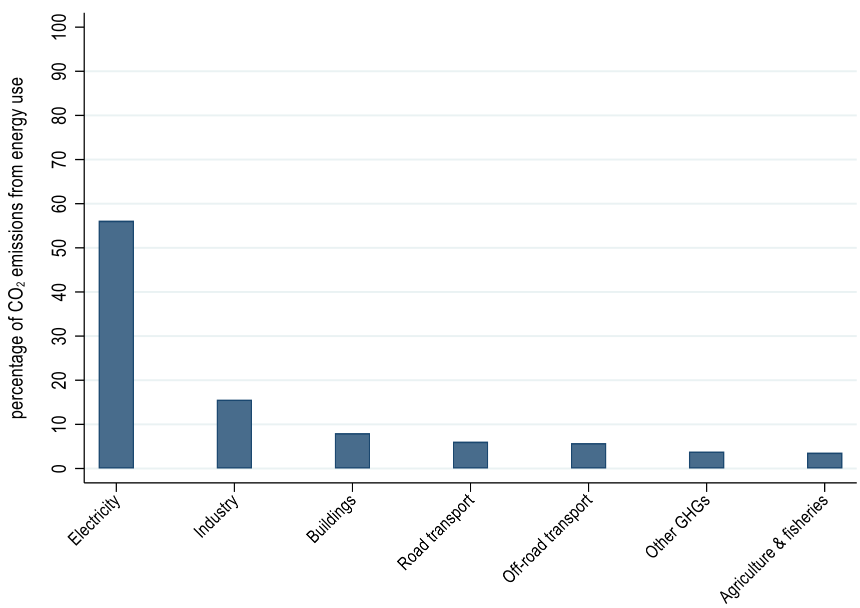
Note: The share presented for Germany separately from the rest of EU ETS countries refers to the share of CO_2 emissions from energy use covered by its national ETS (nationaler Emissionsh andelssystem, or nEHS). The share presented for EU ETS countries is the total share over all EU ETS countries covered 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 CO_2 emissions from biofuel combustion is presented in Annex A. .

StatLink https://stat.link/6xfjvw

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 CO_2 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

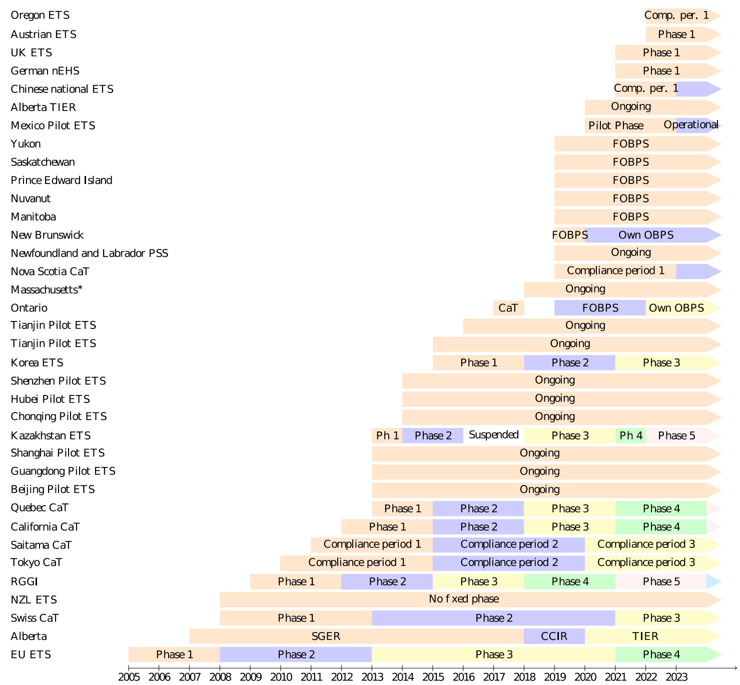


Note: The ETSs considered for the calculations presented in this figure are those present in Table 3.2 (33 ETSs). The equivalent figure when accounting for CO_2 emissions from biofuel combustion is presented in Annex A.

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 grandparenting 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[1]).

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_2O, 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_2O, SF_6, NF_3, HFCs, PFCs	Downstream	Benchmarking	Partial or total earmarking
New Brunswick OBPS	Canada	Electricity, Industry	No	CO_2, CH_4, N_2O, 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_2O, 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_2O, 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_2O, 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_2O, 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, N2O, 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_2O, 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_2O, 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_2O, 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_2O, 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 CO_2, CH_4, and N_2O emissions. As a reminder, upstream regulation focuses on fuel suppliers whereas downstream regulation applies at the point where CO_2 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 2021[10]

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 Islan, 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.

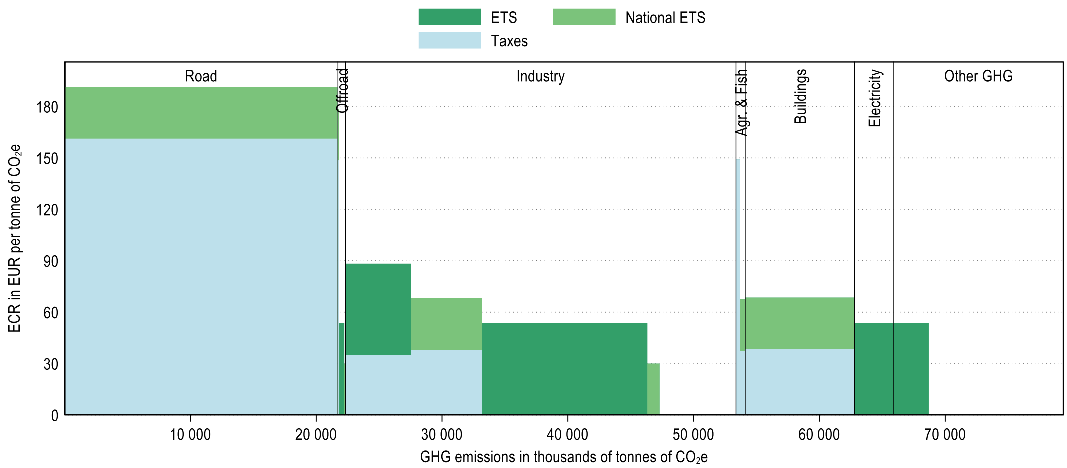
Source: ICAP allowance price explorer (ICAP, 2023[23]), Nova Scotia Cap-and-Trade Program (2023[24]), Mizuho Research & Technologies, Ltd. (2022[25]), Government of Canada (2023[26]), Government of Canada (2023[27]), Greenhouse Gas Pollution Pricing Act (2023[28]), Massachusetts Department of Environmental 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/tCO_2 through permit prices only in 2023 and 18.3% the EUR 60/tCO_2 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/tCO_2. 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 40[15] 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 CO_2 emissions from energy use are based on the IEA World Energy Balances (IEA, 2023[32]).

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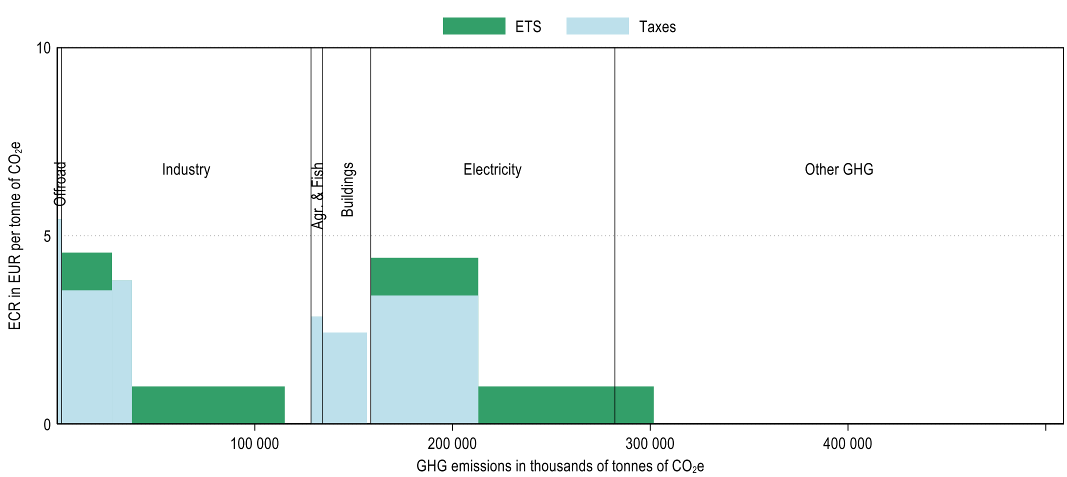
Figure 3.5. Mexico ECR

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/tCO_2 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 CO_2. 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 CO_2 emissions from energy use are based on the IEA World Energy Balances (IEA, 2023[32]).

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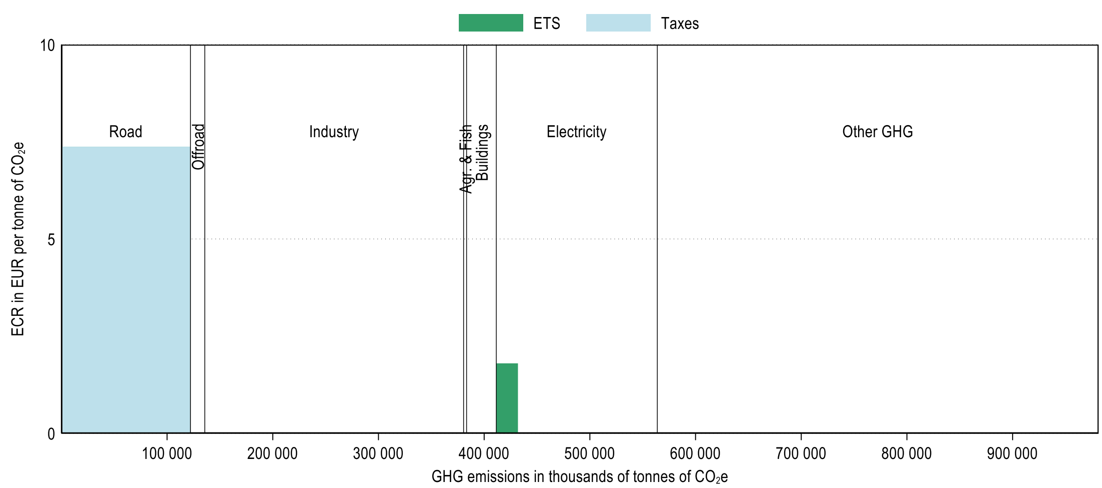
In 2022, five countries had established a mandate for a country-level ETS and were drafting rules for it (ICAP, 2022[8]). Two of these were in South East Asia (Indonesia and Vietnam), two in the Europe and

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 CO_2 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/tCO_2.

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/tCO_2 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 CO_2 emissions from energy use are based on the IEA World Energy Balances (IEA, 2023[32]).

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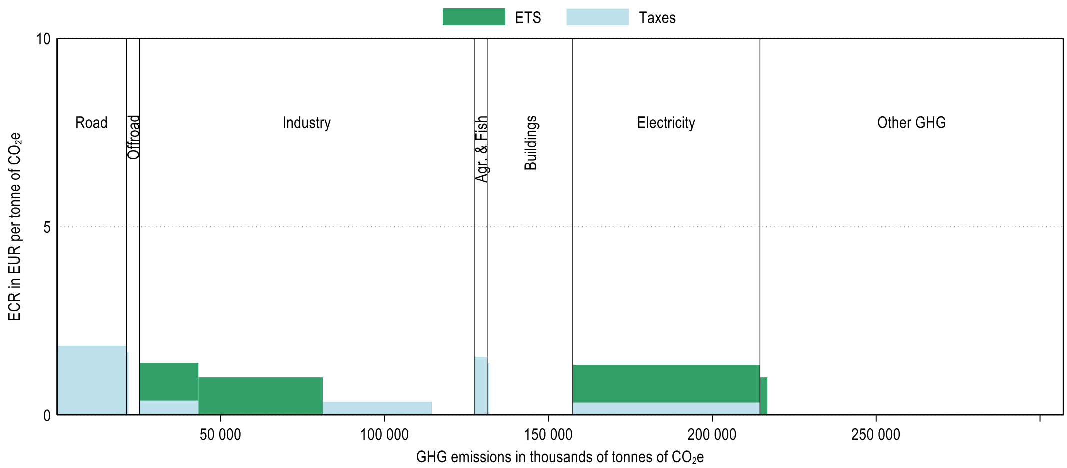
Figure 3.7. Simulated Ukraine ECR profile

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/tCO_2 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 CO_2 emissions from energy use are based on the IEA World Energy Balances (IEA, 2023[32]).

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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 CO_2 emissions from energy use, which may rely on fuel use. New initiatives are emerging to measure non-CO_2 emissions through satellite data[19], 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]).

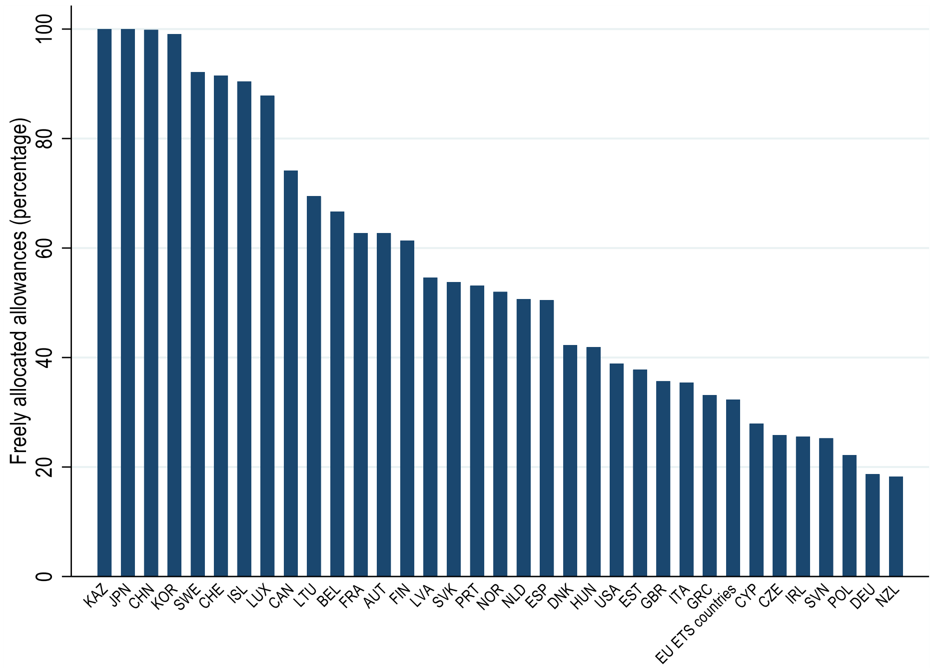
Accounting for affordability, social and political concerns can be key for the successful introduction of carbon pricing schemes in new sectors, especially the agricultural sector. In many countries, climate mitigation and reaching net-zero goals depends to a large extent on reducing GHG emissions in 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 emissions[20] 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.

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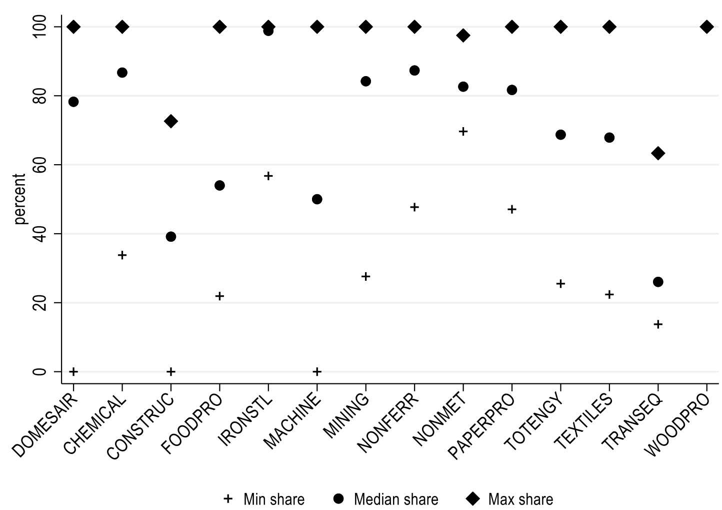
Most emissions trading systems are introduced with a high share of free allocation, for reasons including competitiveness and carbon leakage concerns as well as to build support from covered entities or sectors more generally. Allocating free allowances can ease the transition for industries with carbon-intensive 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 un the sample. When freely allocated allowances are greater than verified emissions (overallocation of free allowances), the share was normalised to 1 (or 100%).

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Emissions allowances may be freely allocated using grandparenting, 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 grandparenting 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 affect 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 average[22] 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, Neuhoff 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 favour 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/tCO_2 and EUR 27.14/tCO_2, 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-negligeable 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])).

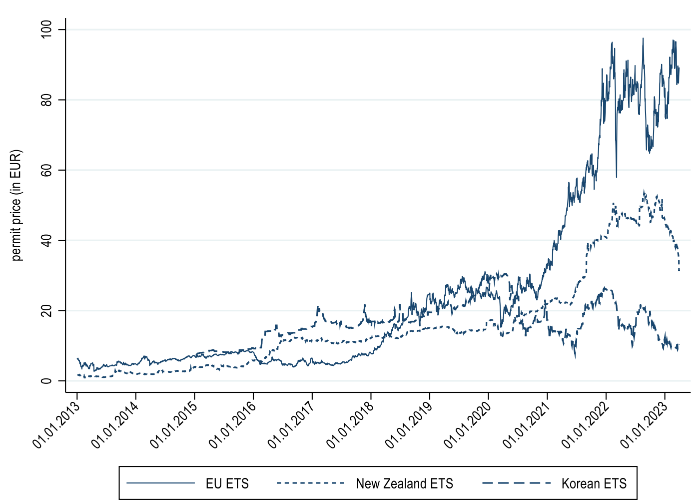
Finally, even with careful use of revenues, competitiveness and carbon leakage arising from asymmetric carbon mitigation efforts and lack of international coordination can remain an issue. An alternative to free allocation can be to implement a border carbon adjustment (BCA). Energy-intensive-trade-exposed (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).

StatLink https://stat.link/te9vw4

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 CO_2.

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 Islan, 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]).

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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 founds, 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 CO_2 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 (Calì 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]). Naegele 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 CO_2 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 CO_2 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 CO_2 emissions from energy use.

[15] Almost 59% if restricting attention to CO_2 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.

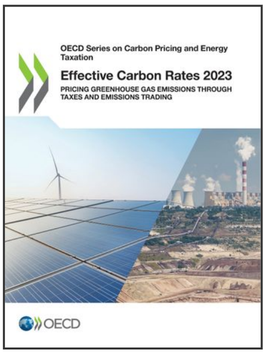
[20] For example, programs such as Overseer^FM can help farmers better manage their intrants and get a better grip of their environmental impacts.

[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).



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