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Policy Options for Climate Change Mitigation:

Emissions Trading Schemes in Asia-Pacific

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Policy Options for Climate Mitigation: Emissions Trading Schemes in Asia-Pacific
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ABSTRACT: Large reductions in global emissions are needed for the world to be on track to meet global temperature goals. Asia-Pacific countries have a critical role in emissions reduction given their large and rising share in global emissions. This paper discusses the main opportunities and behavioral responses for reducing emissions, and commonly used mitigation instruments. It then considers key design issues for carbon pricing, with a focus on emissions trading schemes (ETS), describes measures to overcome the obstacles to carbon pricing, and discusses experiences with carbon pricing relevant for Asia-Pacific economies. Lastly, the paper covers complementary policy reforms, including reinforcing mitigation instruments, public investment, fuel tax reform, green industrial policies, and supporting reforms to the energy sector. Carbon pricing, including ETSs can be the centerpiece of climate mitigation strategies for most countries, particularly if ETSs are designed to mimic some of the administrative and economic attractions of carbon taxes and implemented appropriately.

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Contents

Introduction

Temperatures are rising around the globe causing increased frequency and severity of weather-related natural disasters (Alonso and others, 2021). By mid-century, rising waters combined with migration to low-lying areas and coastal cities will impact nearly a billion people in the Asia-Pacific region and coastal megacities run the risk of being submerged (Neumann and others, 2015). For small Pacific Island countries, rising sea levels pose an existential threat. While suffering the consequences, the region is also a major contributor to global emissions today. Though Asian countries are not responsible for most of the existing stock of carbon in the atmosphere and they have lower emissions on a per capita basis than other regions, the region currently produces about half of the world's carbon dioxide (CO_2) emissions and contains five of the ten largest greenhouse-gas-emitting countries (Alonso and others, 2021). Asian countries therefore have a pivotal role to play in helping to achieve the 25 or 50 percent reduction in global greenhouse gases (GHGs) below recent levels needed by 2030 to get on track with limiting global warming to 2 or 1.5°C, while maintaining the principle of common but differentiated responsibilities formalized under the Paris Agreement (Black and others 2023).

In response to both the significant rise in emissions and subsequent climate threats, Asia-Pacific countries are increasingly implementing new policies to support climate change mitigation strategies, including carbon pricing and non-pricing schemes. Carbon pricing is potentially the most effective mitigation instrument and is gaining momentum globally, not least in Asia-Pacific. The politics of carbon pricing are not easy however as carbon pricing has a more significant impact on energy prices than other instruments. This in turn implies larger burdens on various—perhaps politically influential—groups. While there are options for addressing these burdens, most likely policymakers will need to strike a balance between carbon pricing and less efficient, but likely more acceptable instruments. There will also need to be coordinated global solutions to ensure the climate transition is just, equitable and orderly consistent with country-specific circumstances, which may include concessional and adequate finance along with technology transfer to developing countries.

This paper briefly discusses the main opportunities and behavioral responses for reducing emissions and commonly used mitigation instruments. It then considers key design issues for carbon pricing, with a focus on emissions trading schemes (ETS). Measures to overcome the obstacles to carbon pricing are then described. Following that, experiences with carbon pricing in other countries are discussed. Lastly, the paper covers complementary policy reforms, including reinforcing mitigation instruments, public investment, fuel tax reform, green industrial policies, and supporting reforms to the energy sector.

Throughout this paper the experiences of countries in Asia-Pacific are highlighted. ETSs already exist in some countries in the region including China, Korea, and New Zealand and are under consideration or recently implemented in several others including India, Indonesia, Thailand, and Vietnam, while Singapore has implemented a carbon tax. It is important for countries to learn from each other's experiences in order to design and implement schemes that are administratively practical and will have the greatest emissions reduction benefits while sharing the cost burden equitably across households and businesses.

Mitigation Basics: Mitigation Opportunities and Commonly Used Mitigation Instruments

Table 1 provides a classification of the potential opportunities or behavioral responses for reducing GHG emissions by key emitting sectors. Responses can be classified as follows:

- *Fuel/input switching:* for example, in power generation shifting from coal to gas and from these fuels to renewables and nuclear; in transport shifting from gasoline/diesel vehicles to electric vehicles (EVs); in buildings switching from gas/oil to electric heating.
- *Energy/production efficiency:* for example, shifting sales to more fuel-efficient internal combustion engine vehicles; adopting more efficient heating/cooling equipment, lighting, and appliances in buildings; shifting to more productive livestock herds.
- *Emissions capture*: for example, adopting carbon capture and storage (CCS) at power plant and industrial smokestacks; promoting forest carbon sequestration through afforestation, reduced deforestation and enhanced forest management; collecting methane leaks at fuel extraction sites and landfills.
- *Demand responses*: for example, reducing driving, heating, meat consumption. The Mission LiFE in India, which propose sustainable living, is one such example of policy promoting a demand response.

Table 1. Examples of Behavioral Responses for Reducing GHGs by Sector

Sector		Type of Response			
		Fuel/input switching	Energy/production efficiency	Emissions capture	Demand reduction
Main energy sectors	Power (supply-side)	Coal→gas; fossil fuels→nuclear, wind, solar, hydro, other renewables	Heat optimization	CCS	na
	Industry	Coal→gas; fossil fuels→electric, hydrogen; clinker substitution	Energy efficient machinery	CCS	Conserving on use of steel, cement
	Transport	Gasoline/diesel→ electric	Low→high fuel economy vehicles	na	Reducing vehicle km travelled
	Buildings	Gas/oil heating/cooking→ electric	More efficient heating/cooling, lighting, appliances, insulation	na	Using less heating/cooling
Broader sectors	Agriculture	Changing feed to reduce enteric fermentation	Higher productivity livestock	Covering manure, using for biogas	Meat → plant-based diet; reducing food waste
	Forestry	na	na	Afforestation, reducing deforestation, forest management	Reducing demand for timber and agricultrual products
	Extractives (supply-side)	na	na	Capture of vented methane for on-site power or sales; leak detection and repair	na
	Waste	na	na	Collection/flaring landfill gas	Recycling, composting, reducing demand for packaging

Source: Authors.

Table 2 summarizes commonly used mitigation instruments, examples of sectors where they apply, along with a classification of the instruments and the usual ministry responsible for administration. The instruments include:

Carbon tax: this imposes a charge on the carbon content of fossil fuel supply or (less commonly) on emissions when fuels are combusted, typically with the tax rate ramping up progressively over time.

ETS: requires firms to hold allowances for their emissions or less commonly for the carbon content of fuel supply, the government caps the total quantity of allowances and progressively scales back the cap over time in line with emissions commitments—allowance/emissions prices are determined in trading markets.

Feebate: applies a sliding scale of fees to products or activities with emission rates above a pivot point level and sliding scale of rebates to products or activities with emission rates below the pivot point.

Performance standard: requires firms to meet an emission rate or energy efficiency standard but, with credit trading, they can fall short of the standard by purchasing credits from firms exceeding the standard.

Clean technology subsidy: subsidy or tax credit for a firm or household adopting a clean technology or fuel.

Clean technology mandate: specifies minimum requirements for adoption or use of a clean technology.

Energy taxes: increasing existing (or imposing new) taxes on fossil fuel products or electricity.

These instruments can be classified into pricing versus non-pricing instruments where this distinction refers to whether the instrument prices unabated emissions for the average firm or household (carbon tax, ETS) or not (all other instruments). They can also be classified as regulatory specifying a quantity for absolute emissions (ETS), rates of emissions or energy efficiency (performance standards), technologies (technology mandate) or fiscal, that is, specifying a rate of tax or subsidy (all other instruments). Regulatory and fiscal instruments are typically under the purview of environmental/energy and finance ministries respectively.

From a pure economics lens, carbon pricing is potentially the most effective mitigation instrument, if comprehensively applied. As carbon prices are passed forward into higher prices for fossil fuels, electricity, and energy intensive goods, they promote the full range of behavioral responses for reducing energy use and shifting to cleaner energy sources. It is also cost effective because it provides the same reward for reducing emissions by an extra (metric) tonne, namely the carbon price, across sectors and fuels—see Annex 1 for a conceptual discussion of mitigation costs and how they can be minimized. Pricing can also mobilize a valuable source of new revenues.

Feebates and (tradable) performance standards can cost-effectively promote the full range of behavioral responses for reducing the emissions intensity of particular sectors but (unlike carbon pricing) they do not promote a demand response. For example, if applied to the transportation sector, they will encourage the transition to cleaner vehicles, but they do not encourage people to drive less. And these instruments do not raise revenue.

Clean technology subsidies and mandates promote a narrower range of behavioral responses for reducing emissions intensity. For example, incentives for renewable generation do not promote shifting from coal to gas generation or shifting from these fuels to nuclear.

Table 2. Classification of Commonly Used Mitigation Instruments

Instrument	Definition	Common examples	Classification		Usual ministry responsible
			Pricing/ non-pricing	Fiscal/ regulatory	
Carbon tax	Charge on the carbon content of fossil fuels or their emissions	Applied to fossil fuel sales	Pricing	Fiscal	Finance
Emissions trading system (ETS)	Require firms to hold allowances for their emissions or carbon content of their fuel supply. The government controls the supply of allowances and emissions prices are determined in allowance trading markets.	Applied to large emitters in power and industry	Pricing	Regulatory	Environment
Feebates	Sliding scale of fees on products/activities with emission rates above a pivot point and a sliding scale of rebates for products/activities with emission rates below the pivot point.	Integrated into vehicle registration tax systems	Non-pricing	Fiscal	Finance
Performance standards	Require firms to meet an emission rate or energy efficiency standard but (with credit trading) firms can fall short of the standard by purchasing tradable credits from firms exceeding the standard.	Applied to industrial firms; fuel economy standards for vehicle sales fleets; efficiency standards for appliances	Non-pricing	Regulatory	Environment/ energy
Clean technology subsidy	Subsidy or tax credit for adopting a clean technology or fuel	Feed in tariffs or production tax credits for renewables; tax credits for EVs	Non-pricing	Fiscal	Environment/ finance
Clean technology mandate	Specifies minimum requirements for adoption or use of a clean technology	Renewable portfolio standards (RPS) for generators; manufacturer sales share requirements for EVs	Non-pricing	Regulatory	Environment/ energy
Energy taxes	Increasing existing (or imposing new) taxes on fossil fuel products or electricty	Excise taxes on road fuels, other fuels, and electricity	Pricing	Fiscal	Finance

Source: Authors. Note: Pricing refers to whether the instrument charges for unabated emissions.

Key Design Issues for ETSs

A. Administration and Coverage

ETSs are usually applied downstream to large emitting firms in the power and industrial sector. Firms are required to submit annual reports on their emissions and, once they have been verified by an accredited third-party, they must then acquire a sufficient number of allowances to cover these emissions. With full compliance, the total amount of emissions is equal to the cap on emissions allowances, which is fixed by the government. Allowances can either be given away to firms for free, or auctioned by the government, or (most commonly) some combination of the two. Sufficient penalties may be needed to deter non-compliance and there is risk that actual emissions will exceed the cap, perhaps with penalties based on some multiple of the prevailing allowance price times the difference between reported emissions and allowance holdings. Once implemented, changes to the rules governing an ETS tend to require changes to regulations and legislation, which may involve a lengthy process of notice and consultation.

One possible reason for a downstream focus in ETSs is that they extend pre-existing regulations for local pollution by regulated entities (firms and plants). Another might be pressure for free allowance allocation from downstream firms. And pricing emissions out of the smokestack rewards all mitigation responses in the power and industry sector, including reductions in process emissions (for example, during manufacture of cement from limestone) and possible adoption of CCS (whereas carbon taxes on fossil fuel supply require supplementary payment schemes to address the latter responses).

At the same time, a focus on downstream emissions and trading markets has some drawbacks:

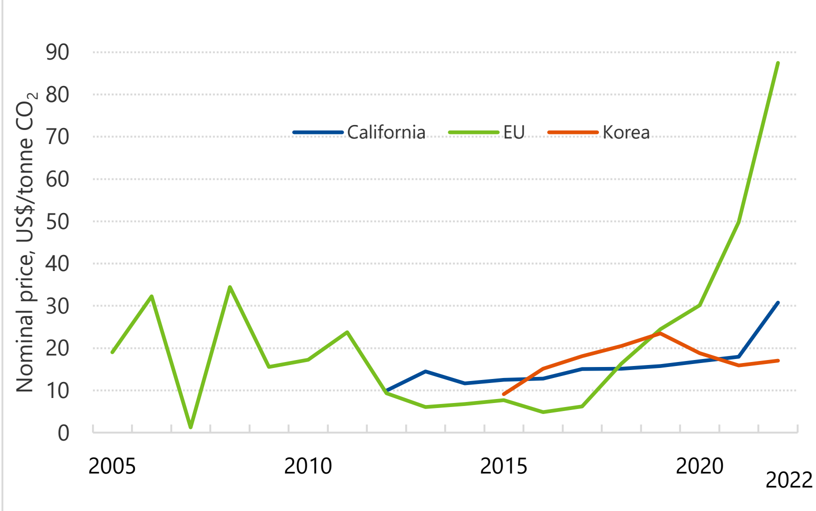
- *Monitoring emissions*: new capacity is required to monitor downstream emissions, for example, through requiring firms to install continuous emissions monitoring systems in smokestacks or monitoring their fuel inputs and applying emissions factors;
- *Monitoring trading markets*: capacity is also required to supervise allowance registries and market trading;
- *Small emitter exemptions*: to limit administrative burdens (given that most firms throughout the economy use some fossil fuels), small-scale emitters are excluded from ETSs though their share in sector-wide emissions is not that large.

Another possibility is to apply ETSs midstream to fuel suppliers where firms already monitor their output and emissions are easily inferred by applying emissions factors for different fuels—midstream application is standard for carbon taxes. Indeed, ETSs need to be applied midstream to cover transportation and building fuels suppliers, though this duplicates existing capacity for collection of road fuel excises. ETSs could also be applied to upstream to methane emissions from extractives (for example, coal mining) but again this would duplicate administration of fiscal regimes for these firms, and it would require firms to self-report emissions. Pricing for the agricultural sector may be impractical for the time being, as farm level emissions are not monitored, and a large portion of farming may be in the informal sector.

B. Addressing Price Volatility

ETSs provide certainty over emissions, which are fixed by the cap, but the price of allowances varies with market conditions (like changes in fuel prices and the availability and costs of clean technologies). Conversely, carbon taxes can provide certainty over emissions prices (the tax rate) but emissions will vary with market conditions.

Figure 1. Allowance Price Volatility in ETSs



Sources: CarbonCredits.com; Korea Exchange; and WBG (2023).

Certainty over emissions is attractive if policymakers want to meet an emissions target in a future year and policymakers can ensure (perhaps legally binding) emissions commitments in a particular year are set through appropriate setting of the emissions cap. But price uncertainty can deter private innovation in, and adoption of, clean technologies, especially those with high upfront costs (for example, renewables plants) and long-range emissions reductions. Indeed, ETS schemes have shown significant price volatility to date (Figure 1).

ETSs can however be combined with mechanisms to limit allowance price volatility. A common example is a price floor (for example, specifying a minimum price at allowance auctions), which reduces the supply of allowances when the price is binding. The government can also set a ceiling price if there are concerns about the risks of high emissions prices, whereby the supply of allowances is increased if allowance prices reach a trigger level. Price floors tend to raise government revenues from allowance auctions (as they increase the sales price) while price ceilings limit revenues.

C. Compatibility with Overlapping Instruments

ETSs need to be designed to be compatible with overlapping instruments like clean technology and energy efficiency policies—the latter instruments may be important elements of mitigation strategies to enhance overall acceptability or advance low-carbon technologies. If these overlapping policies are superimposed on top of a pure ETS, they reduce emissions prices but not emissions (which are fixed by the ETS cap). Underpinning the ETS with a floor price can improve compatibility, however—where the price floor binds (inducing it to behave more like a carbon tax), overlapping instruments will cause allowances to be removed from the system, thereby lowering emissions. Alternatively, the sequence of future ETS emissions caps can be tightened over time to account for the effect of overlapping instruments.

In some cases, ETSs may perform the role of a backstop, where the primary focus of the mitigation policy is a regulatory or fiscal approach. For example, California has an aggressive set of renewable requirements for power generation, vehicle emission rate standards, and energy efficiency requirements though the absolute emissions effects of these policies is uncertain (for example, emissions will vary with how much new and used vehicles are driven)—the ETS ensures that emissions reductions are achieved, regardless of the effect of these regulations. At the same time, a floor price under the ETS can maintain a robust price signal from the system. From the point of view of economic efficiency, however, it is best to have the ETS play the central role, with complementary regulations if needed in sectors like transport and buildings which are hard to abate (that is, that would require high carbon prices to substantially cut their emissions).

D. Allowance Allocations

There are three main options for allocating allowances in ETSs including (see Table 3 for a summary):

Table 3. Trade-offs Across Alternative Allowance Allocations

Metric	Allowance Allocation under ETS		
	Free	Auctioned--revenue to general government	Auctions--revenue earmarked for low carbon investment
Household incidence	Rents accrue to better off households through windfall profits to firms	Revenues can be recycled in an equitable way to households	Investments benefitting low-income households could be targetted
Environmental impact	Could retard exit of polluting firms	No direct impact on emissions	Reduces emissions or lowers the cost of meeting a given emissions cap
Competitveness	Free allocation to industry mostly compensates for higher production costs	Does not address burdens on energy-intensive trade exposed firms	Does not address burdens on energy-intensive trade exposed firms
Economic efficiency	No efficiency benefit	Revenues can be used to cut disrtorting taxes of fund productive general investment	Earmarked spending may be less efficient than general revenue uses
Political acceptability	Helps to address opposition from firms but not households	Revenue recycling may garner some support	May garner support from recipients of investment

Sources: Authors. Green indicates an advantage of an allocation mechanism, red a disadvantage, and amber neither an advantage nor disadvantage.

Free allocation: allowances are given away free to firms based on formulas linked to their past emissions or production levels.[1] This can help to compensate firms for higher production costs which helps with competitiveness and may head off political opposition from firms. But this approach forgoes efficiency benefits from revenue recycling and worsens distributional outcomes as it creates windfall profits for firms which ultimately accrue to shareholders (who are concentrated in higher income groups). Free allocation may also retard the replacement of older emissions intensive firms with new cleaner firms as free allocations are cancelled if firms exit the industry.

Auctioning—revenue to general government: with allowances sold at auction governments collect revenues which could be used for assisting low-income households and for productive general purposes like cutting distortionary taxes or funding public investments for Sustainable Development Goals. Some revenues might also be used to compensate firms for competitiveness losses, though this diverts revenues from the general budget.

Auctioning—earmarking: alternatively, revenues from allowances sold at auction might be earmarked for climate investments which helps with environmental objectives (for example, funding supporting infrastructure like grid upgrades to accommodate renewables). Earmarking however may not be the most efficient use of the revenues and it does not address competitiveness concerns.

Addressing Obstacles to Pricing

A. Assisting Households

At the economywide level, the initial burden of a carbon pricing policy on firms before revenue recycling consists of the abatement costs (the costs of the induced reduction in emissions) and the charges on

[1] In the latter case, allocations might depend on production scaled by an emissions intensity benchmark based on relatively clean firms in the industry.

unabated emissions.[2] Most of this burden is ultimately borne by households through higher prices for energy products and general consumer goods as firms respond to higher production costs by passing them forward in higher prices—some of the burden may also take the form of reductions in labor and capital income to the extent the burden of carbon pricing is passed back to firms in lower producer prices.

There are two broad approaches for addressing distributional burdens on households and policymakers may need to strike a balance between them. One is to move ahead with revenue-raising carbon pricing and recycle the revenues in ways that address poverty and fairness goals.[3] The other is to instead rely on non-pricing instruments which have much smaller impacts on energy costs and consumer prices but do not raise revenues to offset these burdens.

Potential income and energy price support measures that could be funded with carbon pricing revenues include:

Partially targeted income support. In many emerging market economies in Asia social safety net systems have incomplete coverage of the poor and may have significant leakage of benefits to the non-poor. Channeling revenues through them will be only partially effective at assisting low-income households and will have sizable fiscal costs. Recycling carbon pricing revenues in payroll tax rebates or investments for Sustainable Development Goals raise similar issues in regard to compensating the poor (for example, those not working in the formal sector or not located near investment projects do not benefit), but the recycling does at least improve economic efficiency (through strengthening incentives for work effort or funding projects with favorable benefit/cost ratios).

Targeted energy price support. This might include rebates on energy bills for low-income households which effectively compensate households for higher energy prices at modest fiscal cost, leaving most carbon pricing revenues for general purposes. These rebates however do not compensate for higher prices of non-energy-intensive consumer goods, may (moderately) suppress energy demand reductions, and (most importantly) may be challenging to administer. Block tariffs (where households pay lower unit costs for the first block of consumption) are another option and may be practical where electricity is metered, though they can also involve significant leakage to higher income households (where all households face the same tariff structure).

Broad-based energy price support. Using some carbon pricing revenues to contain increases in electricity prices (for example, through subsidies for local distribution companies) is worse than targeted energy bill rebates in that it involves both a larger fiscal cost and larger suppression of demand reductions but is a more realistic option from an administrative perspective.

B. Industrial Competitiveness

While competitiveness concerns apply in principle to all traded items, the policy focus has been on energy-intensive, trade-exposed (EITE) industries. This is because their costs are most heavily increased by carbon mitigation policy (since their production is fuel and energy intensive) and there is a reasonable presumption that domestic mitigation policy may induce some shifting in these industries from domestic to

[2] Under a carbon tax this is the tax paid on remaining emissions; under an ETS with allowance auctions it is the cost of purchasing allowances to cover emissions; under an ETS with free allowance allocation it is the foregone revenue from using allowances to cover the firms' emissions rather than selling them to other firms.

[3] See IMF (2022) Annex Table 2.1 for a detailed list of national, subnational, and regional level carbon pricing schemes in operations whose revenues is recycled. These includes several countries in Asia, including Indonesia and Singapore (carbon tax, recycled to general budget), Korea (ETS, recycled to environmental spending), and Japan (hybrid carbon price, recycled to environmental spending)

foreign production. EITE industries account for over 80 percent of industrial emissions in China, India, and Korea.[4]

Under carbon pricing for industry and power sector emissions, industrial production costs per unit increase through three channels:

- *Abatement costs*: arising from induced reductions in the direct emissions intensity of production;
- *Charges on unabated emissions*: reflecting remaining direct emissions times the emissions price; and
- *Higher electricity input costs*: amounting to emissions embodied in electricity inputs per unit of production times the emissions price.

See Annex 2 for some discussion of the impacts of carbon pricing on industrial productions costs for selected countries. Under feebates/performance standards, the first channel above applies, the second does not, while the third will depend on the mitigation instrument applied to the power sector.

With no international policy coordination, there are two broad approaches for addressing competitiveness concerns:

- *Not raising net revenues from the EITE sectors:* this approach keeps the revenues or rents from charges on unabated emissions within the EITE sector. This might include giving free allowances to firms, recycling revenues from auctioned allowances collected from EITE industries back to the sector (for example, in output-based rebates), or applying feebates/performance standards to this sector rather than carbon pricing. All these approaches may be manageable from an administrative perspective, but they divert revenue from general purposes, and they are less robust for addressing competitiveness at deeper levels of decarbonization as they do not compensate for abatement costs.
- *Border carbon adjustments (BCAs)*: sometimes called carbon border adjustment mechanisms (CBAMs), these instruments impose charges on embodied carbon in products imported into a jurisdiction with carbon pricing, possibly matched by rebates for embodied carbon in domestic exports. See Keen and others (2022) for a detailed discussion of BCAs.

More generally, international policy coordination over carbon pricing could provide much more comprehensive incentives for international emissions reductions. In this case, emissions in products coming into the domestic economy would be priced (as under a BCA) but also emissions released within the borders of trading partners.

C. Assisting Workers and Regions in Asia-Pacific Countries

Many Asia-Pacific economies rely heavily on coal. For example, in India, the Ministry of Power recently announced it will not close any coal-fired power plants before 2030 (even those meant to retire earlier) and will invest in an additional 75-80 GW of coal fired power plants this decade. This carbon lock-in may delay investment in, and deployment of, modern renewable energy infrastructure, and complicate the path towards meeting long-term climate objectives. In China, almost 70 percent of power is generated from coal and is primarily consumed by China’s extensive industrial sector which has supported the country’s investment-intensive growth model. Further, substantial construction of new coal-fired power plant capacity has continued and even accelerated since the blackouts in 2021, signifying a carbon lock-in and possibly posing challenges to China’s long-term climate ambitions.[5] Other countries in Southeast

[4] Keen and others (2022), Figure 2.

[5] See Chateau and others (2022) and CREA (2023). The building of new coal power plants may not necessarily endanger meeting China’s climate goals, as the Chinese authorities plan to have excess coal capacity for emergency use, but risks remain (China Dialogue, 2023, More renewables, more coal: Where are China’s emissions really headed? | Dialogue Earth).

Asia, such as Indonesia and Vietnam, have both significant and young coal capacity, suggesting that, despite ambitious climate goals, reducing coal emissions will take many years to be realized. How might assistance measures ease the transition away from coal?

Coal mining is often concentrated in a few regions, especially in large countries like China and India, implying sizable job losses in communities with limited alternative employment opportunities. Evidence from both advanced and emerging market economies show that high wages in the coal sector can distort local economies, and when coal is eventually phased out the transitions (including finding new jobs for coal workers) can take a long time, especially in remote communities with little economic diversification (Bulmer and others, 2021). Assistance for reclaiming abandoned mining and drilling sites and temporary budget support for local governments could help to create employment and bridge the transition for adversely affected communities.[6] Additional investments or other geographically targeted policies (for example, subsidies or grants to individuals or firms in affected regions) may also help regions engage in economically viable and sustainable opportunities.[7] In China, there are increasing efforts to pair coal power plants with renewable power plants, in order to mitigate the effect on local communities. Annex 3 summarizes measures used in Germany which has especially comprehensive programs to assist workers and regions for the transition away from coal and may provide useful lessons for Asia-Pacific economies.

Other measures for displaced workers might include extended unemployment benefits, training and reemployment services, and financial assistance for job search, relocation, and health care. Outreach to increase awareness and take up of the programs, tailoring of job training to the needs of workers, and wage insurance or tax credits, especially for older workers, could also help. The estimated cost of programs providing comprehensive benefits to displaced workers is generally a small fraction of potential carbon pricing revenues.[8] Indeed coal-related job losses are small in macro terms and tend to be offset over time by expanding job opportunities in clean energy sectors. Furthermore, there is evidence that support for carbon pricing in Asia-Pacific countries could increase if revenue recycling were targeted towards renewable energy projects and supporting the development of green technology (Dabla-Norris and others, 2023b).

[6] For example, China established a restructuring fund in 2015 (costing 0.15 percent of GDP), mainly for training and job search assistance to facilitate the shutdown of coal mines.

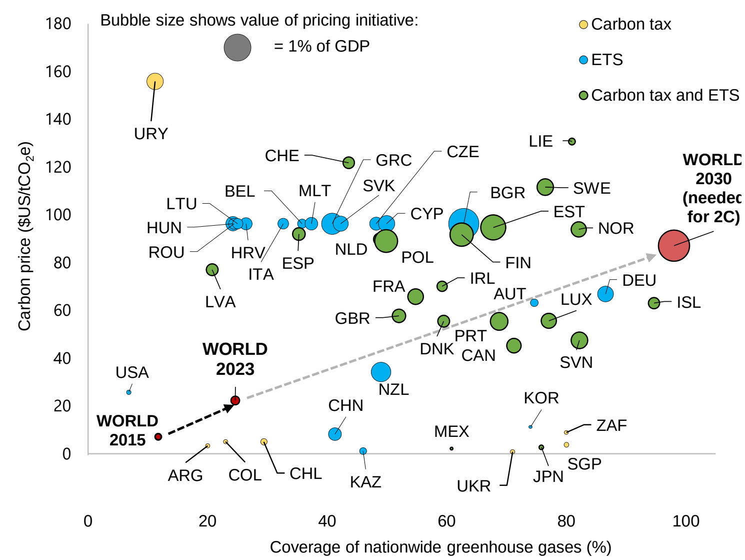
[7] See for example WBG (2018).

[8] See for example Morris (2016).

Experience with ETSs and Carbon Pricing to Date in Asia-Pacific

Carbon pricing schemes are proliferating, having doubled in coverage of global GHG emissions since 2015. See Figure 2 and, for more details on individual schemes including coverage, prices, revenues (and their use), and point of regulation, Annex 4.

Figure 2. Carbon Pricing Schemes at National, Sub-National, and Regional Level, 2023



Sources: WBG (2023); IMF Staff; national sources.

As of end 2023, 73 carbon pricing schemes were operating in 47 countries, covering 25 percent of global GHGs. This includes 30 carbon taxes and nine ETSs implemented at the national level and the EU ETS prices emissions in EU and European Free Trade Association countries. Many subnational pricing schemes are also operating, the largest being California's ETS. National coverage of emissions varies, from below 30 percent in some cases to more than 70 percent in others (for example, Canada, Germany, Korea, Sweden). Carbon prices vary from below $5 to over $100 per tonne (mostly in European countries). The average (emissions weighted) price of covered emissions has grown from $7 in 2015 to about $22 in 2023. Carbon prices differ across jurisdiction due to the policy environment and anticipated changes in policy, including changes in the floor price, more ambitious climate targets, and tightened ETS rules. Other factors include speculative investment, and broader economic trends including commodity prices (World Bank, 2022).

When including uncovered emissions however, the current global average emissions price is only $5 per tonne, a small fraction of the increase in carbon pricing or emissions-equivalent measures by 2030 even for a 2°C target. Moreover, fuel excises can provide similar incentives as carbon pricing and they have been modestly declining at the global level, undermining some of the progress on direct carbon pricing.[9]

In Asia, Korea has introduced an ETS, Singapore a carbon tax, China an intensity based ETS and Indonesia plans to combine an ETS with its existing carbon tax—see Box 1 for details. Pricing schemes are also under consideration in Philippines, Vietnam, and India.

[9] See Black and others (2023), Figure 11.

Box 1. Emissions Pricing Schemes in Asian Countries

China. In January 2021 China launched a nationwide intensity-based ETS (building off pilot carbon market programs in eight regions) and covering around 40 percent of nationwide CO_2 emissions. The scheme currently covers coal and gas-fired power plants and has no cap on total emissions. Allowances are allocated freely according to production levels of coal- and gas-fired power plants and predetermined emissions intensity benchmarks (that is, CO_2 emissions per unit of electricity production). The current allowance allocation plan defines four benchmark categories: three for coal-fired power plants, based on their different technology types, and one for gas power plants. The laxer standards for coal limit incentives to switch away from this fuel to gas, renewables, and nuclear. Trading prices since late 2013 are around US $14 per tonne. The Chinese government intends to extend emissions trading to industry, including petrochemicals, chemicals, building materials, iron and steel, non-ferrous metals, paper, and domestic aviation. See also Black and others (forthcoming) for a discussion of ETS reform options in China.

Indonesia. The introduction of a carbon tax was mandated through Indonesia's tax law (Law No. 7/2021 on Tax Harmonization) at the end of 2021 but has yet to be implemented. It would be initially implemented on coal power plants and start at around US $2 per tonne of CO_2 (a low level relative to recommendations of an average carbon tax of US $40-80 per tonne by the 2018 IPCC by 2020).[10]

On February 22, 2023, the Ministry of Energy and Mineral Resources announced the launch of a mandatory ETS for the power sector, foreseeing a gradual expansion of coverage from on-grid coal-fired power plants (specifically, on-grid facilities with a capacity of more than 100 megawatts) from 2023 onwards, to oil and gas-fired power plants and off-grid coal-fired power plants in the following years. The specific design will be determined in implementing guidelines and will likely be combined with the carbon tax and carbon offset mechanisms.

Korea. Korea launched the first national ETS in East Asia in 2015. The system in Phase 3 (2021-2025) applies to 684 companies—principally power generators and large industrial firms (including iron and steel, petrochemicals, cement, oil refineries, nonferrous metals, paper, textiles, machinery, mining, glass and ceramics) covering three quarters of national GHGs, slightly up from a coverage rate of 70 percent in Phase 2 (2018-2020).[11] The ETS cap cumulated over the three years of Phase 2 was 1,796 $MtCO_{2e}$, or on average 599 $MtCO_{2e}$ a year. In Phase 3 the annual average emissions cap will be reduced 4.7 percent relative to 2017-2019 ETS emissions. Allowances are largely given away for free (based on companies' 2011-2013 emissions) though 10 percent will be auctioned in Phase 3 with revenues earmarked for environmental investments. EITE industries will continue to receive 100 percent free allowance allocations.[12] Auctions are subject to a minimum price based on recent emissions prices rather than an exogenously escalating price—emissions prices have remained around $20 per tonne. Various banking and borrowing provisions, and other market stability provisions, are also designed to limit allowance price volatility.

Singapore. On January 1, 2019, following extensive public consultations by various government agencies and stakeholders, Singapore introduced a tax applying downstream to all facilities in the power and industry sectors with annual direct emissions exceeding 25 kilotons of CO_2 equivalent—collectively these sources account for 80 percent of economywide GHGs. For the first five years the tax rate was set at US$4 (S$5) per

[10] Climate Action Tracker Indonesia Policies and Actions, accessed December 12, 2023 https://climateactiontracker.org/countries/indonesia/policies-action/

[11] Companies with over 125 kilotons, and installations with over 25 kilotons, of annual CO_2 equivalent emissions are covered by the scheme. The construction, public, waste, and domestic aviation sectors are also covered and all six Koyoto GHGs, though other emissions are small relative to CO_2.

[12] EITE sectors are defined along the following criteria: (i) trade intensity of at least 10 percent and the ETS increases production costs for the industry by at least 5 percent; or (ii) production cost increases exceed 30 percent; or (iii) trade intensity exceeds 30 percent.

tonne. Following a review in 2022 the tax rate has increased to US $19 (S $25) per tonne in 2024 and will rise to US$33 (S$45) per tonne in 2026 and 2027, reaching US$60-100 37-59 (S $50-80) per tonne by 2030.

The early announcement provides business with greater certainty in planning. To help maintain business competitiveness in the near term and mitigate the risk of carbon leakage, existing facilities in EITE sectors will receive transitory allowances for part of their emissions, based on efficiency standards and decarbonization targets. Revenues from the tax are used to fund climate initiatives like energy efficiency improvements for industry. Starting From 2024, onwards companies will are also be able to surrender high quality international carbon credits to offset up to 5 percent of their taxable emissions.

Japan. Japan was one of the first Asian countries to implement a carbon tax. In 2012, the Government of Japan announced the Tax for Climate Change Mitigation, legislating a carbon tax at the rate of US $2.7 (JPY 289) per tonne of CO_2 equivalent applied to all fossil fuels on top of the existing petroleum and coal tax. Estimated tax revenue was US $1.5 billion (JPY 234 billion) per year, which was designed to be recycled for promoting transition to low-carbon technology-intensive industries, installation of energy-saving equipment by small and medium enterprises, and financial assistance for Green New Deal Funds used by local governments to implement energy saving and renewable energy in their respective jurisdictions. At its inception, the carbon tax was designed to reduce GHGs 80 percent by 2050. However, its rate has remained too low to reach the country’s target (Gokhale 2021). The government is committed to expanding carbon pricing from current low levels beginning in fiscal year 2028.

Source: WBG (2023), Dabla-Norris and others (2023).

Broader experiences with carbon pricing schemes can provide guidance for policy design in Asia-Pacific countries in regard to:[13]

Emissions measurement: accurate projection of emissions is needed to inform appropriate setting of an ETS cap. For example, in the initial stage of the EU ETS, the EU did not have reliable information about firms’ actual emissions before the market started and largely defined allocations based on (inflated) industry projections—CO_2 prices crashed from around €20-30 per tonne following the first round of emissions verifications in 2005 that showed actual emissions were significantly below the emissions cap.[14]

Price volatility: ideally, to promote investment in low-carbon technologies, ETSs would provide a robust and predictable price signal. In contrast, in the first 15 years of the EU ETS, prices were volatile and depressed, varying between €5 and €30 per tonne (see Figure 1 above) reflecting the oversupply of allowances in the system and the effect of overlapping measures (to promote renewables and energy efficiency). Given that an explicit price floor mechanism might be interpreted as a fiscal measure (requiring unanimity among member states) the EU instead opted to address price volatility through the Market Stability Reserve (MSR) that withdrew allowances from the system when banked allowances exceeded a threshold level. Initially, the MSR had little effect on prices as withdrawn allowances were expected to be put back into the system at a later date. Subsequent revisions to the MSR have allowed withdrawn allowances to be cancelled which was one factor (along with other factors like the tightening emissions cap) causing the recent run up in emissions prices.

[13] Experiences with energy price reform more generally also provide guidance on ingredients for successful policy reform (see for example Coady and others 2018).

[14] Hintermann (2010).

The California ETS includes a price floor implemented through minimum prices when allowances are auctioned with the reserve price rising exogenously at 5 percent annually in real terms—this has enabled a tripling of prices to current levels of around $30 per tonne compared with 2012 prices. Korea has a similar price floor mechanism, but floors are endogenously based on recent historical prices—partly in response to this allowance prices have yet to be on a robust upward trajectory.

Use of emissions offsets. Policymakers should be cautious about allowing international or domestic offsets in ETSs. International or domestic offsets enable one country or sector to forgo some emissions reductions by purchasing emission reduction credits from another country or sector. Most commonly, trades are at the firm level and enable offset purchasers to reduce liabilities under a carbon tax or the need to acquire allowances under an ETS. For international offsets, trade could also occur at the government level allowing one country to exceed emissions targets (in Nationally Determined Contributions for the Paris Agreement) by purchasing offsets from another country that limits emissions below its target.

International offsets however do not reduce total global emissions, unless they indirectly encourage countries (for example, those facing high incremental costs from domestic abatement) to tighten their mitigation pledges. Indeed, the concern has been that international offsets can *increase* global emissions unless the offset is *fully additional* which requires the emission reduction from the offset would not have occurred anyway in the baseline without the offset payment (for example, development of a renewables plant that is profitable before the payment). Similarly, domestic offset schemes will increase total domestic emissions unless the offset is fully additional. Indeed, the EU no longer allows firms covered by its ETS to purchase international offsets in lieu of surrendering allowances. As a result of the limited demand for offsets (due in part to credibility concerns) and potentially abundant supply, offset prices remain highly depressed.

Coverage. Ideally, an ETS has broad coverage, so long as this does not prevent a robust emissions price. New Zealand was an early ETS pioneer, and its system included both the energy sector and the forestry sector but excludes emissions from agriculture. In particular, landowners can gain credits for afforestation projects for sale to the ETS while landowners must buy permits if they reduce forest cover (through deliberate cutting or fires and other accidents). There has been however ample supply of low-cost afforestation projects (for example, displacing marginal sheep farming) which has likely contributed towards a lower ETS allowance price. Indeed, nearly all the emissions reductions under the ETS have come from forestry (especially fast-growing pine trees for rotation farming) rather than mitigation in the energy sector, suggesting a case for keeping pricing schemes for forestry separate from those for the energy sector (to enable a higher price for the latter). Inclusion of a pricing mechanism for agricultural emissions in New Zealand has been delayed to 2030 but remains a key priority given it is the largest emitting sector. Notwithstanding these issues, the ETS is the centerpiece of the authorities' Emissions Reduction Plan and has helped substantially in New Zealand's falling gross emissions since 2019 (IMF, 2023).

Competitiveness. An ETS also needs to address competitiveness concerns, not least to placate industrial interests. The EU is currently phasing in a BCA which will require exporters of steel, cement, fertilizer, aluminum, hydrogen and electricity generation to the EU to buy for allowances for embodied emissions in these exports. The aim of the BCA is to maintain a level playing field for domestic and foreign firms regardless of the domestic emissions price—it will replace the current system of free allowances which effectively provides a subsidy to domestic EITE industries.[15] The BCA will only charge for a very small

[15] The UK has also recently announced it will introduce a BCA by 2027.

portion of nationwide emissions for exporters to the EU—1 percent in the case of China and India[16]—and much of the burden of the BCA will be passed forward to domestic consumers in the EU rather than being borne by foreign suppliers in the form of lower international prices for traded products. Nonetheless, BCAs remain contentious—for example, they put the same price on emissions in trading partners as in the EU ETS, which may go against the spirit of the principle of common but differentiated responsibilities enshrined in the Paris Agreement.

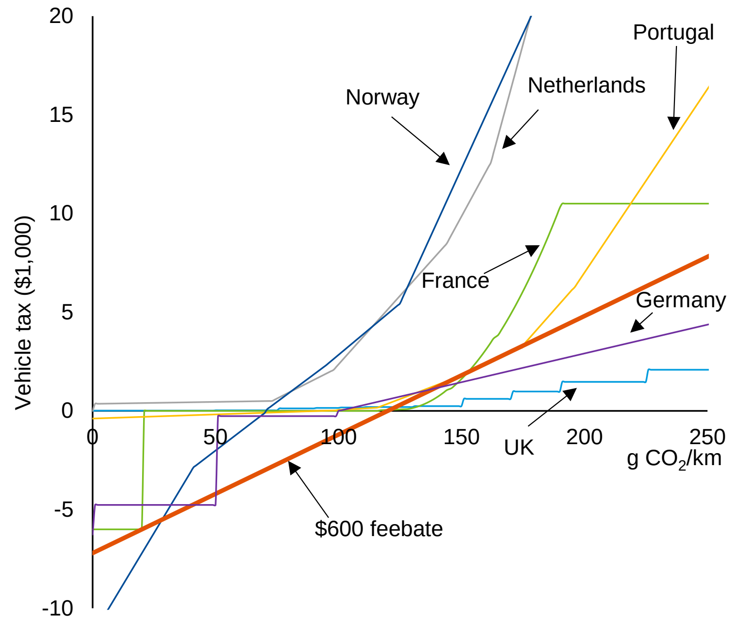
Complementary Policies

A. Reinforcing Mitigation Instruments Policies at the Sectoral Level

There is an important role for emissions mitigation instruments, applied on a sector-by-sector basis, to complement and reinforce carbon pricing. One reason is that there may be constraints on the political acceptability of pricing, given its significant impact on energy prices which in turn imposes burdens on households and firms—indeed in some countries, carbon pricing lacks broad political support. In addition, carbon pricing has limited effectiveness in hard-to-abate sectors like buildings and transport where strong incentives are needed to encourage shifting to clean technologies in line with full decarbonization of the sector by midcentury. Ideally, sectoral instruments are designed to promote a broad range of behavioral responses for cutting emissions.

[16] Keen and others (2022).

Figure 3. CO_2-Based Components of Vehicle Taxes, Selected Countries



Sources: ACEA (2018) and IMF staff calculations. Note: Feebates assume on road fleet average emission rate of 115 g CO2/km. Circulation taxes for Germany are expressed on a lifetime basis assuming a 13-year life and 7 percent discount rate.

Feebates may have greater political acceptability than carbon pricing, as they do not impose a new tax on the average household or firm which helps to address concerns about impacts on households and firm competitiveness. Elements of feebates have been incorporated into vehicle registration tax systems, involving subsidies for zero emission vehicles and rising taxes on vehicles with higher emission rates—indeed in in some European countries implicit carbon prices in feebates are often around $600 per tonne or more (see Figure 3) which has helped promote rapid deployment of electric vehicles in countries like Norway and the Netherlands.

Tradable performance standards—the regulatory analogue of feebates—have many of the same attributes of feebates (they can cost-effectively reduce emissions intensity without a new tax burden on the average firm). They apply, for example, to vehicle sellers in China, India, Korea, the US, and the EU (often in conjunction with feebates).[17]

Feebates and TPSs could also apply to the power generation or industrial sectors to reinforce (or substitute for) carbon pricing though these applications have been less common—Box 2 provides examples for Canada and Netherlands.

Box 2. Examples of Industrial Performance Standards and Feebates[18]

[17] Black and other (2022), Table A5.

[18] For more details see www.canada.ca/en/environment-climate-change/services/climate-change/pricing-pollution-how-it-will-work/output-based-pricing-system/overview.html; IEA (2022a); https://carbonmarketwatch.org/2020/12/21/what-can-we-learn-from-the-dutch-national-carbon-tax.

Canada. Provinces and territories in Canada are required to have a carbon charging system, with the carbon price ramping up from CAN$10 per tonne CO_2 in 2019 to CAN$50 in 2023 and CAN$170 by 2030. A federal carbon pricing backstop system applies in provinces/territories that requested it or that do not meet the federal standard. The backstop has two components: (i) a fuel charge; and (ii) a tradable performance standard for facilities in EITE industries (with annual emissions exceeding 50 kilo tonnes of CO_2 equivalent), known as the Output-Based Pricing System (OBPS). The OBPS currently applies in Manitoba, Prince Edward Island, Yukon, Nunavut, and partially in Saskatchewan (Ontario and New Brunswick recently transitioned from the OBPS to regional versions). The OBPS sets an annual emissions-intensity standard for each facility based on (70 percent of) the production-weighted average emissions intensity of all large emitting facilities producing similar products across Canada. Facilities exceeding the standard are subject to fees on their excess emissions (in line with federal pricing) while those emitting less than their standard earn credits they can sell or bank for future use.

Netherlands. In January 2021, Netherlands introduced a levy on industrial CO_2 emissions equal to any positive difference between an escalating target price (rising to €125 per tonne by 2030) and the prevailing EU ETS price. The levy applies to emissions over and above a pivot point emission rate based on the cleanest ten percent of firms in the industry at the EU-level. Companies with emission rates below the pivot point can sell credits to other firms where the levy is binding.

B. Fuel Tax Reform

For countries with high shares of coal in the energy mix—like China and India—a coal tax is relatively effective at cutting emissions. This is because most of the emissions reduction—over 80 percent in the case of China, India, Indonesia, and Korea[19]—under carbon pricing would come from reduced use of coal rather than reduced use of natural gas and oil. And coal taxes are administratively straightforward, for example, if levied at the mine mouth and (given countries are responsible for emissions within their own borders) rebates for coal exports and taxes on coal imports. Indeed, China and India, for example, already collect specific coal taxes at the mine mouth. This could be helpful in the context of these countries already diversifying the energy mix with the deployment of renewable energy for sustainable development and poverty eradication.

If a coal tax were increased in the presence of a pure ETS, its effects on emissions would be neutralized as they are set by the emissions cap. The effect of a coal tax increase on baseline emissions can, however, be considered and the ETS cap can then be set to close the gap between an emissions target and emissions in the baseline with the coal tax increase.

C. Public Investment

The private sector will likely fund most of the investment expenses for decarbonization. For example, incentivized by pricing and other policies, private firms will invest in renewable power generation and electrified industrial processes, while households will pay for purchases of electric vehicles (EVs), heat pumps, and energy-efficient lighting/appliances. However, investments in infrastructure networks may benefit multiple users and would be undersupplied when left to the market. Examples are pipelines for hydrogen and carbon capture and storage, high voltage transmission lines to link up different sites for renewable plants, and EV charging stations. At present, public investment in clean energy in many middle and low-income countries extends well beyond infrastructure networks as the power sector and certain

[19] Parry and others (2022), Figure 7.

industries in these countries are often dominated by greater state-ownership and electricity prices are regulated. But going forward, the public share in clean energy investment might fall if energy markets are liberalized over time.

Another key issue is how public investment should be financed. Even if a significant share of the power sector remains in public hands, it would still be more efficient to reflect investment costs in higher prices for users (for example, higher electricity tariffs) rather than subsidize the investments from public budgets. This would help promote the efficient allocation of capital and other resources across sectors rather than favoring the power sector over other sectors. The same applies to charging infrastructure for EVs where it would be more efficient to recover investment costs through charges for using these facilities rather than the general budget. Similarly, public sector outlays for the building sector (for example, subsidies for adoption of heat pumps) could be financed within the sector (for example, through higher taxes for residential gas) to avoid subsidizing housing on net relative to other sectors.

D. Industrial Policy

Industrial policy (IP) refers to the government's effort to shape the economy through targeted measures to specific domestic industries, firms, or economic activity. Specifically, it refers to any type of selective government interventions or policies that attempt to alter the structure of production in favor of domestic industries, firms, or activities that are expected to offer better economic prospects for achieving strategic goals (e.g. green transition) in a way that would not occur in the absence of such intervention in the market equilibrium. Green IP refers to those policies that are also aimed at climate change mitigation or adaptation.

In general, the use of IP may be justified in the presence of well-identified externalities, coordination failures or public input under-provision (e.g., ineffective horizontal or untargeted policies). To be effective, IP measures should be well-targeted, time-bound, cost-effective, transparent, and deliver on their objectives, while preserving domestic macroeconomic stability, fiscal and external sustainability. Given the high risk of resource misallocation, IP should be well-designed to mitigate incentives for rent seeking and corruption. Policymakers should avoid IP measures that violate their international commitments, and harm trading partners.

Green IP is subject to many of the same considerations as traditional IP, with the additional aspect that climate change is a global externality and may thus imply additional issues for effective design and implementation. In that context, several principles might guide the design of green IP:

I. Complement core decarbonization policies through policies that accelerate the adoption, innovation, and production of low-carbon technologies.

II. Minimize adverse spillovers, avoid creating technology transfer barriers, especially to developing countries, and avoid inconsistencies with WTO obligations.

III. Ensure support is time-bound, cost-effective, and transparent, while limiting fiscal burdens, other domestic costs, and negative effects on international markets.

IV. Conduct policies within an appropriate institutional framework to minimize implemented risks.

V. Coordinate globally on green IP measures.

There are nonetheless important risks associated with the use of green IP. Green IP could distort resource allocation. This could be, for instance, with provisions that discriminate against foreign manufacturers, making them akin to import restrictions (e.g., tariffs, quotas). They could also induce the relocation of green energy companies to countries with larger tax incentives and subsidies. Such distortions can yield negative cross-border spillovers for trade and investment, and an inefficient allocation of production. Green IP can make governments vulnerable to rent seeking and corruption. As a result, green IP could lead to wasted resources, competitiveness losses or state capture. It is also subject to political risk, as green subsidies may be rejected by voters due to their large fiscal cost, which can complicate international coordination. Green IP also incurs a fiscal cost (versus carbon pricing which generates fiscal revenues). If offset by higher taxes elsewhere, this can exacerbate pre-existing tax distortions and increase the efficiency costs of carbon mitigation.

Given these risks, one needs to make the best choice of green IP policy instruments by identifying the main objective of government interventions while weighing on the costs. For example, the expected net benefits of green IP for the domestic economy should be considered in the cost-benefit analysis. Such analysis should capture direct and indirect costs and benefits for the economy, including fiscal and administrative costs as well as indirect costs due to potential resource misallocation.

In order to accelerate the climate transition, there is an urgent need for policies (including IP) that help spur, scale up, and adopt green technologies across a wide range of sectors, from energy generation to transportation and industry (Cherif et al. 2022). Furthermore, in most Asian countries the need for strong growth and achieving development objectives remains a key priority. Unlike specific environmental policy, green IP can take on many forms and thus may be more flexible to address the twin goals of development and climate change adaptation/mitigation. That said, importing, adopting, producing, and exporting green technologies requires an ever-increasing set of national, firm-level, and human capabilities which countries possess in unequal measures. For instance, China accounts for the bulk of production of critical low-carbon technology products (solar panels, batteries) alongside extraction of the rare earth metals to extract them (Howell and others, 2023). Hence, it may be difficult for many countries to integrate into these markets, irrespective of future market growth. India provides a potentially promising example in its support for the green hydrogen industry which is complementary to its ambitious development and poverty reduction goals. According to the OECD (Cammeraat et al. 2022), the key to successful implementation of green hydrogen IP includes specifically support for research and development, ensuring sufficient supply of renewable energy, establishing clear carbon price trajectories, reducing uncertainty for investors through regulatory action, and considering blue hydrogen as an interim solution.

E. Power Sector Reform

In many countries, the structure of the power sector may be a constraining factor in the shift towards renewable energy and effective carbon pricing. This may be due to limited installed renewable capacity or limited ability to integrate additional renewable capacity, absence of markets for energy storage (given the intermittent nature of renewable energy, low cost and large capacity storage is critical) and other grid support services (including if the sector has substandard frequency control, insufficient reserve capacity that is capable of handling fluctuations in renewable output, and/or inadequate reactive power for voltage control).[20] Furthermore, in many emerging market economies in Asia power demand is growing as incomes rise and dependence on fossil fuels for power generation is often increasing to keep up with this demand. As such, reforms to increase efficiency of the power sector is an important piece of climate policy. It is also important as a support measuring for effective carbon pricing, as the presence of administered pricing, power sector monopolies, and soft budget constraints on SOEs would distort carbon price signals.

India is an example where delayed reforms to the power sector (specifically, electricity distribution companies or DISCOMs) may be delaying further renewable energy adoption. DISCOMs struggle to raise revenues amid underpriced electricity, inadequate subsidy payments and long-term purchase agreements

[20] See, for example, Asian Development Bank (2023) for a discussion of India's power sector constraints.

with electricity generation companies. In addition, they face high energy losses (a combination of technical loss, theft, and inefficiency in billing) and high commercial losses (default in payment and inefficiency in collection). Given their heavy financial losses, DISCOMs have generally under-invested in improving power distribution or in upgrading the energy distribution infrastructure. Political economy constraints have historically impeded reforms to DISCOMs and to their pricing structure. Furthermore, DISCOMs' payment delays to renewable energy generators act as one of the major barriers to scaling up renewable energy in India (see Chateau and others (2023) for additional discussion). The Government of India has undertaken several initiatives to resolve DISCOM debt stress, and this is work in progress as loss making DISCOMs remain prevalent in many states. This includes among other schemes, the Ministry of Power's Revamped Distribution Sector Scheme, additionally borrowing space of 0.5% of gross state domestic production for states who are undertaking power sector reforms, and additional prudential norms for lending by Power Finance Corporation Limited.

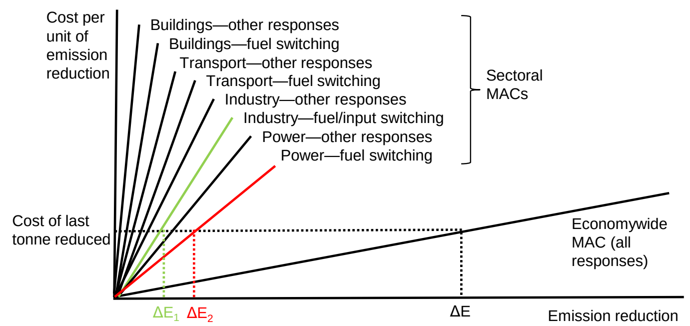
Looking ahead, schemes to reform the power sector are critical as many power distribution and transmission companies will likely face a hit to their financial stability (from revenue loss), distribution system issues (from reactive power, voltage impacts and reverse power flows) and demand forecast uncertainty as renewable energy ramps up.

Conclusions

Designed and implemented appropriately, carbon pricing can be the centerpiece of climate mitigation strategies for most countries. Pricing can promote a wide range of behavioral responses for reducing emissions, mobilize a valuable source of revenue, and impose generally manageable transitional costs on the economy which are counteracted by potential economic gains through revenue recycling and significant domestic environmental co-benefits. While carbon taxes are simpler from an administrative perspective (as an extension of existing fuel taxes), policymakers may prefer ETSs for other reasons—for example, this approach is more natural if mitigation policy is under the purview of the environmental ministry rather than the finance ministry. And ETSs can be designed (for example through price floors and allowance auctions) to mimic some of the economic attractions of carbon taxes while midstream application to fuel suppliers might simplify administration. A variety of additional measures will be needed however, not least given the difficulty of pricing given its impact on energy prices. The strategy will require a balance between pricing and reinforcing instruments like feebates, productive and equitable use of carbon pricing revenues, just transition measures for vulnerable groups, pricing of broader emissions sources, public investment in enabling infrastructure which the private sector may underinvest in, and extensive public communication and stakeholder consultation. Designing and implementing policy packages that cut emissions while ensuring a just transition, ideally with carbon pricing at their core, will be key to achieving climate targets and, ultimately, the Paris Agreement's goals. Additionally, at the global level there will need to be coordinated solutions to ensure the climate transition is just, equitable and orderly consistent with country-specific circumstances which may include concessional and adequate finance along with technology transfer to developing countries.

Annex 1. Least Cost Mitigation Strategies

Figure A1. Least Cost Mitigation Strategies



Source: Authors. Note: The relative position of sectoral MACs will vary with country circumstances.

The mitigation costs for an individual or a set of behavioral responses to reduce emissions depend on the marginal abatement cost (MAC) curves for these responses. These curves show, for any level of emissions reductions, the incremental cost from reducing emissions by one extra tonne through pushing harder on the behavioral response(s). The MAC curve is upward sloping because it is increasingly costly to cut emissions—for example, coal plants with longer remaining economic lives might need to be closed while new renewables plants might need to be located in remote sites with less favorable sunlight and wind conditions. Cutting economywide emissions at least cost involves exploiting potential mitigation responses across all sectors up to the point where the cost of the last tonne reduced is equated across sectors. In Figure A1, for example, for an economywide emissions reduction of ΔE, this would involve emissions reductions of ΔE_1 and ΔE_2 from fuel/input switching in industry, power generation, and so on. Under least cost mitigation strategies, within a sector fuel/input switching typically accounts for the largest share of emissions reductions, and for countries with significant coal use, across sectors, power generation accounts for the largest share of reductions, followed by industry.[21]

[21] Parry and others (2022), Figure 7.

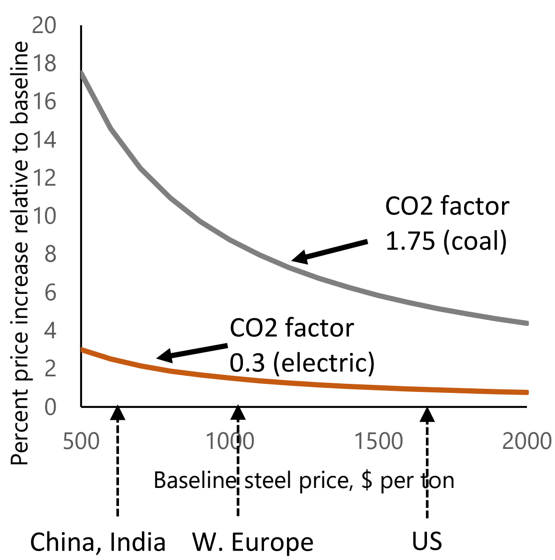
Annex 2. Illustrative Impacts on Industrial Production Cost from Mitigation Policies

Figure A2 shows the impacts on production costs for steel and cement production under, for illustration, a $50 carbon price for 2022 (on direct emissions only) for selected countries. In China and India, the carbon price would cause absolute cost increases for coal-based steel production that are broadly similar to increases in other countries given only limited differences in emission rates per unit of production—but in percentage terms cost increases are larger for China and India (about 15 percent) than for, say, the US, given smaller baseline prices for steel in the former cases. Cost increases would be much smaller for electric- rather than coal-based steel, but this is currently more prevalent in the US and Europe than in Asia (electric production relies on recycled steel).

In contrast, impacts on production costs for cement are much larger both relative to steel and relative to other countries—about 50 percent increase in production costs relative to baseline prices in China and India. Even though the CO_2 emissions factor per ton of cement output is less than half of that per ton of coal-based steel output, the proportionate production cost increases for cement are much higher due to the much lower baseline prices per ton of output. .

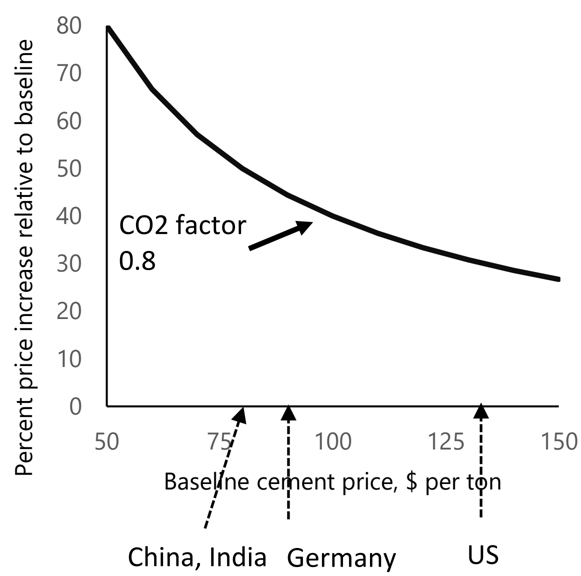
Figure A2. Illustrative Production Cost Increases for Steel and Cement under $50 Carbon Price, 2022

A. Steel



Source: Authors. CO_2 factor is tonnes CO_2 per tonne of steel.

B. Cement



Source: Authors. Note: CO_2 factor is tonnes CO_2 per tonne of cement.

Annex 3. Policies to Assist German Coal Miners and Communities

Table A1 provides a summary of measures to assist coal miners and mining communities in the transition away from coal in Germany.

Table A1. Examples of Ongoing Measures to Assist Displaced Coal Workers and Coal Mining Regions in Germany

Goals		Examples of mechanisms						
Overacrhing	Specific	Financial support (from national government, EU, banks)			Service and assistance			Infrastructure investment
		Public and non-profit organizations	Firms	Workers	Public and non-profit organizations	Firms	Workers	
Economic reorientation and diversification	Support new/existing small/medium (non-coal) firms	Land acquistion, local infrastructure construction, office conversions	Loans, tax cuts, debt repayment schemes		Assistance in creating strategies and networks	Network building, country counselling for exporting companies		
	Expand educational activities	Implementation/ extension of universities/training centers			Creation/support of networks between firms/research institutions			
	Technology development	Clean technology R&D support for universities	Clean technology R&D support for universities			Innovation transfer between research institutions/firms		
	Preserve energy role beyond coal	Clean technology R&D support for universities				Network between universities/firms		
Workforce support	Allowances		Subsidies for employers paying share of allowances	Wage subsidies, unemployment allowances, transitional aid			Help with application for allowances	
	Training programs	Support for creating/extending training facilities	Subsidies for employers pating share of training				Counseling workers fo training programs	
	Job-seeking assistance	Payments to firms for employing the unemployed					Counseling to find jobs	
	Job creation		Financial support for firms creating jobs					Jobs in environmental remediation
Social well-being and quality of life	Urban development	Upgrading municipalities (e.g., buildings, parks)		Modernization of houses				
	Culture and leisure	Creation/operation of cultural/leisure facilities						
Environmental remediation and protection	Decommissioning/environmental rehabilitation	Construction of sewage plants	Incentives for air quality measured/ decommissioning mining sites					
	Water management	Safeguarding nature, water monitoring/cleaning in mines						
	Other	Restortation/ extension of forest areas						

Annex 4. Further Details on Carbon Pricing Schemes

Country/ Region	Year Introduced	Coverage of Energy Sectors: Power	Industry	Transport	Buildings	Coverage Rate, all GHGs (percent)	Price, $/tonne	Revenue/ Rent, % GDP	Point of Tax/ Regulation	Revenue Use
Carbon Taxes										
Argentina	2018	✓	✓	✓		20	5	0.070	Midstream	General budget
Colombia	2017	✓	✓	✓	✓	23	5	0.04	Midstream	Environmental spending
Chile	2017	✓	✓			29	5	0.05	Downstream	General budget
Indonesia	2022	✓				26	2	0.05	Midstream	General budget
Singapore	2019	✓	✓			80	4	0.04	Midstream	Environmental spending
South Africa	2019	✓	✓	✓	✓	80	10	0.04	Midstream	General budget
Ukraine	2011	✓	✓		✓	71	1	0.05	Midstream	General budget
Uruguay	2022		✓	✓		11	127	1.15	Midstream	General budget, environmental spending
ETSs										
EU	2005	✓	✓			41	87	0.26	Downstream	General budget, environmental spending
Austria	2005	✓	✓			37	87	0.11	Downstream	General budget, environmental spending
Belgium	2005	✓	✓			38	87	0.19	Downstream	General budget, environmental spending
Bulgaria	2005	✓	✓			52	87	1.82	Downstream	General budget, environmental spending
Croatia	2005	✓	✓			32	87	0.33	Downstream	General budget, environmental spending
Cyprus	2005	✓	✓			51	87	0.43	Downstream	General budget, environmental spending
China	2013, 2014, 2016, 2021	✓				38	9	0.32	Downstream	Environmental spending proposal
Czech Republic	2005	✓	✓			51	87	0.78	Downstream	General budget, environmental spending
Germany	2005, 2021	✓	✓	✓	✓	85	62	0.44	Mid & Downstream	Environmental spending
Greece	2005	✓	✓			47	87	0.66	Downstream	General budget, environmental spending
Hungary	2005	✓	✓			30	87	0.39	Downstream	General budget, environmental spending
Italy	2005	✓	✓			34	87	0.18	Downstream	General budget, environmental spending
Kazakhstan	2013	✓	✓		✓	46	1	0.10	Downstream	General budget
Korea	2015	✓	✓	✓	✓	73	19	0.99	Downstream	Environmental spending
Lithuania	2005	✓	✓			30	87	0.44	Downstream	General budget, environmental spending
Malta	2005	✓	✓			34	87	0.28	Downstream	General budget, environmental spending
New Zealand	2008	✓	✓	✓		49	53	0.20	Downstream	General budget, environmental spending
Romania	2005	✓	✓			33	87	0.89	Downstream	General budget, environmental spending
Slovakia	2005	✓	✓			50	87	0.64	Downstream	General budget, environmental spending
US	2009, 2012, 2018, 2021	✓	✓	✓	✓	7	24	0.05	Up & Midstream	General budget, direct transfers, environmental spending
Hybrid										
Canada	2019	✓	✓	✓	✓	67	38	0.16	Downstream	Tax cuts, environmental spending
Denmark	1992, 2005	✓	✓	✓	✓	62	52	0.29	Mid & Downstream	General budget
Estonia	2000, 2005	✓	✓			63	79	1.26	Mid & Downstream	General budget
Finland	1990, 2005	✓	✓	✓	✓	67	77	0.76	Mid & Downstream	General budget, tax cuts
France	2005, 2014	✓	✓	✓	✓	56	64	0.41	Mid & Downstream	General budget, environmental spending
Iceland	2005, 2010	✓	✓	✓	✓	93	56	0.62	Mid & Downstream	General budget
Ireland	2005, 2010	✓	✓	✓	✓	59	62	0.23	Mid & Downstream	General budget,direct transfers, environmental spending
Mexico	2014, 2020	✓	✓	✓	✓	61	4	0.02	Midstream	General budget
Japan	2010, 2011, 2012	✓	✓	✓	✓	77	2	0.05	Midstream	Environmental spending
Latvia	2004, 2005	✓	✓			25.4	79	0.39	Midstream	General budget
Liechtenstein	2005, 2008	✓	✓	✓	✓	81	130	0.60	Mid & Downstream	General budget
Luxembourg	2005, 2021	✓	✓	✓	✓	79	38	0.048	Mid & Downstream	General budget
Netherlands	2005, 2021	✓	✓			46	87	0.270	Mid & Downstream	General budget
Norway	1991, 2005	✓	✓	✓	✓	55	87	0.94	Mid & Downstream	General budget
Poland	1990, 2005	✓	✓	✓	✓	51	81	1.45	Mid & Downstream	Environmental spending
Portugal	2015, 2005	✓	✓	✓	✓	70	56	0.52	Mid & Downstream	General budget, environmental spending
Slovenia	1996, 2005	✓	✓	✓	✓	89	47	0.48	Mid & Downstream	General budget
Spain	2005, 2014	✓	✓		✓	37	82	0.25	Mid & Downstream	General budget, environmental spending
Sweden	1991, 2005	✓	✓	✓	✓	77	109	0.52	Mid & Downstream	General budget
UK	2013, 2021	✓	✓			49	67	0.42	Downstream	General budget, tax cuts
Switzerland	2008	✓	✓		✓	44	114	0.16	Midstream	Tax cuts, direct transfers, environmental spending

Sources: Parry and others (2022).

Note Revenue/rent excludes revenue loss from erosion of prior fuel tax bases. Values combine national, subnational and regional pricing. Mexico does not include subnational pricing schemes due to lack of coverage data.

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