Carbon pricing options for Taiwan

Report prepared for Taiwan Environmental Protection Administration

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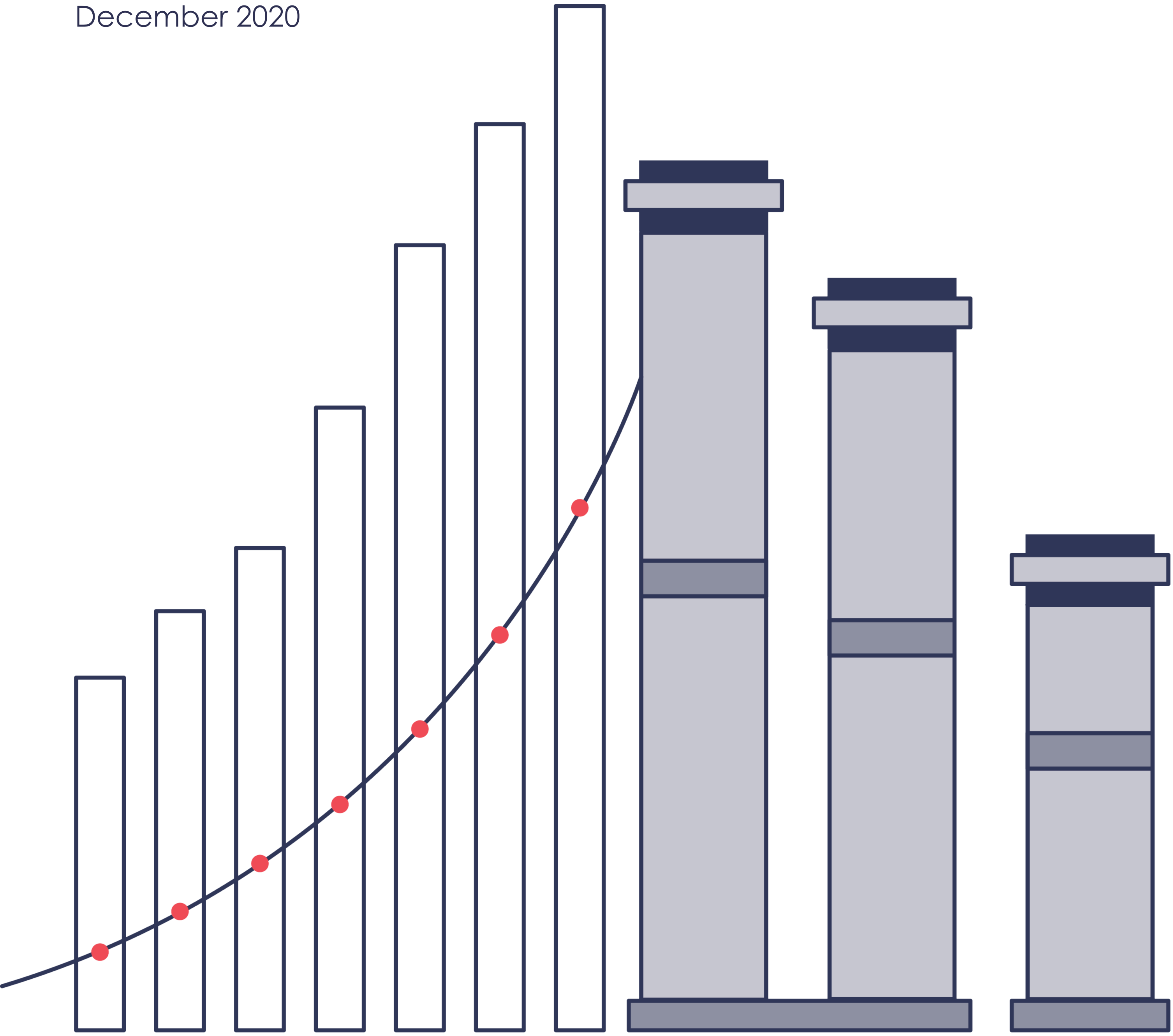

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Executive summary

Headline points

- Carbon pricing alongside complementary policies can help Taiwan reduce its greenhouse gas emissions. Designed well, carbon pricing policy represents a powerful tool for Taiwan to incentivise fair and cost-effective emissions mitigation while growing its economy and playing its part in the international effort to combat climate change.
- Taiwan's major sources of emissions, notably the electricity sector, need to be covered by a carbon price. Consideration must be given specifically to the different options for regulating Taipower, the vertically integrated public utility.
- The potential impacts of carbon pricing on Taiwan's competitiveness need to be managed. As a small, open economy, detailed consideration must be given to the potential risk of carbon leakage and to policy options to reduce this risk.
- Taiwan is at different stages of 'readiness' in terms of its existing capacity to implement different types of carbon pricing instruments. It has most of the capacity required for implementing a carbon levy soon, but further capacity-building would be necessary to implement an emissions trading system (ETS).
- If Taiwan implemented an ETS, the functioning of the secondary market would need to be developed. The relatively small size of its market and the concentration of emissions in a small number of players could lead to challenges regarding the concentration of market power and liquidity in secondary markets.

High level recommendations

1. **Taiwan should start with a simple carbon levy, set at an initially low level, but with a clear trajectory to reach higher prices.**
   By starting with a low price Taiwan can learn by doing, to understand the operation of the levy and its impacts on covered firms. However, a clear trajectory of price increases over time is needed to ensure sufficient decarbonisation incentives.
2. **Taiwan should retain the option of altering the design of its carbon pricing over time, as circumstances change.**
   The simple approach we recommend can be designed with inbuilt flexibility, enabling the policy to be improved over time and providing the opportunity to move to an emissions trading system (ETS) if desired at a future date.
3. **Taiwan should cover the full set of greenhouse gases from large emitters in manufacturing and, if possible, electricity generation.**
   The focus on large emitters complements the pre-existing reporting of emissions for large emitters. The electricity sector is a large source of emissions in Taiwan and its inclusion would cover the indirect emissions of households and the services sector.

Stronger policy action is required for Taiwan to achieve its emissions target

The dangers from inaction on climate change are stark, which calls for accelerated action in Taiwan as it does around the world. Annual greenhouse gas emissions in Taiwan reached a record high in 2007. Although estimates indicate that annual emissions have fallen since then, new policies including the introduction of carbon pricing are needed in order to reach its 2050 target of a 50 per cent reduction relative to 2005 levels, as set down in the Greenhouse Gas Reduction Act of 2015. The Act also requires the Government to implement an emissions trading system (ETS). However, policy progress on this measure has been limited due to unresolved issues on the design and potential impact of an ETS. Taiwan's Environmental Protection Administration (EPA) is expected to propose an amendment to the Act in late 2020, which could allow the use of a carbon levy as a complement to an ETS.

Why carbon pricing?

Carbon pricing, implemented alongside complementary policies, can help Taiwan reduce emissions in a fair and cost-effective way. Without one it will be difficult to achieve emissions reductions. In line with the 'polluter pays' principle, putting a price on greenhouse gas emissions makes businesses and consumers internalise the costs of emissions, incentivising them to make reductions. As a market-based policy tool, the expectation is that once emitters are confronted with the full cost of their actions through a carbon price, they will find ways to reduce their emissions. How exactly they do this is left to them, rather than prescribed by a regulator. This flexibility is associated with economic efficiencies as the cost of abating emissions is lower overall than alternative policies such as subsidies or command-and-control regulations.

As well as achieving emissions targets, carbon pricing can help underpin low-carbon investment, raise fiscal revenue, generate economic, environmental and social co-benefits, and spur international cooperation.

Growing international momentum for carbon pricing

More than 60 jurisdictions worldwide are now benefiting from a carbon pricing instrument. Alongside domestic carbon prices (or where no carbon price exists at all), focus is now turning to alternative ways of dealing with the asymmetry of carbon prices across jurisdictions, to mitigate any potential loss of competitiveness. In this regard border carbon adjustments (BCAs) are being considered as a mechanism that would not only address carbon leakage and competitiveness concerns, but also leverage other jurisdictions' participation in climate agreements. For economies that are yet to enact ambitious climate policy, or those that desire decarbonisation but are undecided about the appropriate policy pathway – such as Taiwan – the potential introduction of such measures may be the start of a global regime where trade relations are affected by climate ambition. This is another reason why carbon pricing policy should be a near-term priority.

The importance of understanding context when implementing carbon pricing

Taiwan's economic profile, energy system and institutional context are all crucial considerations. As a small, export-oriented economy that imports fossil fuels for most of its energy demand, Taiwan faces a range of challenges in reaching its emissions target. In particular, the energy transition requires a significant shift away from fossil fuels, which currently make up 92 per cent of its primary energy supply and are almost entirely imported. The electricity market is dominated by Taipower, a vertically integrated public utility which generates over 70 per cent of electricity in Taiwan and is the sole company responsible for transmitting and distributing electricity. The market is being liberalised under the Electricity Act Amendment in 2017 and how this is regulated will be important for the future of carbon pricing in Taiwan.

The manufacturing sector is an important stakeholder to consider when implementing a carbon price, being directly responsible or an indirect source for more than half of Taiwan's emissions. About 75 per cent of manufacturing gross value added (GVA) and 65 per cent of employment relates to the production of electronic components, petrochemical and coal products, and metals. Almost all of Taiwan's manufacturing is trade-exposed and competes on international markets. This is different to many jurisdictions that have implemented carbon pricing where some manufacturing subsectors may be more reliant on domestic markets.

Factors to consider when choosing a carbon pricing instrument

Taiwan is likely to choose to implement either a carbon levy or an ETS. In theory, these two carbon pricing instruments (CPIs) could achieve the exact same outcomes in a given time period if there is no uncertainty and the instruments are calibrated to produce the same carbon price. In practice, however, factors including uncertainty regarding the future trajectory of emissions, the cost of mitigation, broader economic circumstances, political economy considerations and the ability to give away free allowances under an ETS mean that these instruments have important differences, which often dictate the choice between the two in the short and long run. It can be helpful to distinguish short-run barriers (often political, legal, and institutional factors) from long-run objectives (environmental outcomes, economic efficiency, and competent policy administration) when evaluating the viability of CPIs.

In the short run, ease of administration and simplicity of policy design and implementation are often important factors in determining what type of CPI is feasible. It can take significant time to build the capacity needed to support effective carbon markets. In particular, policy design for an ETS has to address the challenges from illiquid or uncompetitive markets. In contrast, a carbon levy is comparatively simple and can often be implemented by simply building on systems established for existing energy and environmental taxes. When assessing these legal and institutional factors, introducing a carbon tax may appear the easier choice. However, political factors may make the introduction of a certain type of policy infeasible. This is a particularly important issue for carbon taxes, given people's aversion to taxes generally, and to carbon taxes more specifically. A thorough examination of what is politically possible may therefore lead policymakers to choose an instrument that looks comparatively worse on legal or institutional grounds but has far greater political feasibility, such as an ETS.

In the long run, differences in the fundamental attributes of carbon levies and ETSs may determine the longer-run development of a carbon pricing policy. This means that understanding the fundamental objectives of a jurisdiction in introducing carbon pricing should influence its longer-term development.

These short- and long-run considerations are summarised in the figure on the next page.

Several barriers could influence the choice of carbon pricing in the short run:

- Coverage of the electricity sector
- Industrial competitiveness, carbon leakage and wider economic impact
- Risks of concentrated market power and insufficient liquidity in an ETS
- Capacity for implementation

These four considerations emerge from a careful analysis of Taiwan's emissions trends, economic structure and energy system, and discussions with the EPA, facilitated by a questionnaire regarding local context and capacity. While the consideration of market power and liquidity is only relevant to implementing an ETS, the other three considerations are relevant to any form of carbon pricing, whether it is based on a carbon levy or an ETS. Each consideration poses unique challenges to implementing carbon pricing in Taiwan and should therefore be treated carefully by policymakers.

Key considerations for carbon pricing in Taiwan

Short-run instrument choice

Implementation capacity
→ Carbon levy preferred
Industry is more familiar with fees but averse to the administrative burden of ETS trading. It takes time to develop rules for market oversight and trading infrastructure.

Secondary market challenges
→ Carbon levy preferred
Taiwan must address the lack of liquidity and concentrated market power if an ETS is used. Options include purchasing and holding limits, frequent auctions, consignment auctions, and expanding ETS scope.

Short-run instrument design

Regulated electricity sector
→ Cover the sector if possible
Taipower can be regulated by a carbon levy after an amendment to the GHG Act. Pass carbon costs to electricity users via a consumption charge on indirect emissions.

Impact on competitiveness
→ Support to mitigate impact
Cost impact will focus on emissions-intensive and trade-exposed industries and can be addressed effectively in both a levy and an ETS. Carbon costs in indirect emissions via electricity use will have limited impact on the wider economy.

Long-run instrument choice and design

Achieving emissions targets
→ **ETS** offers greater certainty in limiting emissions to a fixed level

Long-run cost-effectiveness
→ **ETS** offers temporal flexibility but higher administrative costs

Support low-carbon investment
→ **ETS** offers temporal flexibility but higher administrative costs

Raise government revenue
→ **Levy** may be a more predictable revenue source

Generating co-benefits
→ **Both ETS and a levy** can deliver local co-benefits, e.g. air quality

International cooperation
→ **ETS** linking can improve cost efficiency and build political ties

Conclusions

This study presents the first steps and broad parameters for the introduction of a carbon price but further action is required to move towards implementation. This includes clarification of the policy design details and the development of enabling legislation. Thorough stakeholder consultation and capacity-building will be essential to ensure that the policies adopted are fit for purpose.

We have presented a flexible approach for Taiwan's short-run carbon pricing implementation; in the long run the development of the policy should evolve in line with Taiwan's underlying policy objectives. Carbon pricing is a powerful policy tool, and as such jurisdictions often trade several objectives when deciding on the type of carbon price to adopt. For Taiwan, the key question will be whether to retain a carbon levy or to move to an ETS as its context, capabilities and objectives each change. This choice should be informed by a structured assessment of the role that carbon pricing plays in Taiwan's broader environmental, economic, fiscal and foreign policy.

1. Introduction

The dangers from inaction on climate change are stark, which calls for accelerated action in Taiwan as it does globally. Annual greenhouse gas emissions in Taiwan reached a record high in 2017. Although estimates indicate that annual emissions have fallen since then, stronger action is needed for Taiwan to reach its 2050 target of a 50 per cent reduction relative to 2005 levels. The Greenhouse Gas Reduction Act of 2015 requires the Government to implement an emissions trading scheme (ETS). However, policy progress on this measure has been limited due to unresolved issues on the design and potential impact of an ETS. Taiwan's Environmental Protection Administration (EPA) is expected to propose an amendment to the Act in late 2020, which could allow the use of a carbon levy as an alternative to an ETS.

This report argues that carbon pricing alongside complementary policies can help Taiwan reduce emissions in a fair and cost-effective way. It assesses the options for carbon pricing in Taiwan and seeks to identify the key elements of a successful policy approach. In so doing it identifies a clear path to carbon pricing in Taiwan.

Current shortfalls in climate change action in Taiwan

Under the 2015 Paris Agreement nearly 200 countries committed to hold "the increase in the global average temperature to well below 2°C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5°C". In the same year, Taiwan (not a party to the Paris Agreement) passed the 2015 Greenhouse Gas Reduction and Management Act (known as the GHG Act), which commits Taiwan to reducing greenhouse gas emissions to 50 per cent below 2005 levels by 2050. However, the latest evidence from the Intergovernmental Panel on Climate Change shows that globally, emissions may have to fall to 'net zero' levels by 2050 to achieve the Paris Agreement targets (IPCC, 2018).

Stronger policy action is required for Taiwan to achieve its emissions target. Total greenhouse gas emissions in Taiwan have grown steadily since 2010, with the latest figure, from 2017, standing at 299 megatonnes of carbon dioxide equivalent ($MtCO_2e$), 95 per cent of which is carbon dioxide and 90 per cent is emitted from the combustion of fossil fuels (EPA, 2019a). Growth in emissions has been underpinned by increased emissions from electricity generation and road transport. This is despite recent efforts to reform the electricity market, subsidise the deployment of renewable energy, and incentivise businesses to adopt energy efficiency measures.

A carbon price can be one of the key policies to reducing emissions in Taiwan. Despite accelerating international action on climate change and after more than a decade of public debate on carbon pricing in Taiwan, it has yet to introduce a carbon price. The EPA first submitted a draft of the GHG Bill in 2006, which included a call for emissions trading alongside other measures to reduce emissions. The draft Bill faced significant opposition from industries concerned about the economic impact of carbon pricing and from environmental groups concerned that the Bill did not include a specific emissions reduction target. In the years that followed, legislative progress stalled with a lack of consensus on the timescale and ambition needed for emissions reductions. It was not until 2015 that the GHG Act passed into law with bipartisan support for stronger climate action. Under Article 18 of the GHG Act, the Government is mandated to implement an ETS. However, five years on from the passage of the Act, Taiwan has yet to implement an ETS or choose a carbon pricing instrument. Barriers to its implementation have included concerns around the market functioning of an ETS, regulatory capacity, impact on industry, and a lack of political consensus over the role of a carbon price.

Why carbon pricing?

Today's emissions will cause widespread social, economic and environmental costs in the future. These impacts are 'externalities' that are not factored into decision-making; nor do the prices of goods or services account for the costs of emissions. In line with the 'polluter pays' principle, putting a price on greenhouse gas emissions makes businesses and consumers internalise the costs of emissions, incentivising them to make reductions. It also raises the relative price of carbon-intensive goods for consumers, inducing them to reduce their consumption. As a market-based policy tool, the expectation is that once emitters are confronted with the full cost of their actions through a carbon price, they will find ways to reduce their emissions. How exactly they do this is left to them, rather than prescribed by a regulator. This flexibility is associated with economic efficiencies as the cost of abating emissions is lower overall than alternative policies such as subsidies or command-and-control regulations (Best et al., 2020; Doda and Fankhauser, 2020).

Carbon pricing is any policy that creates a direct price for the emission of carbon dioxide or other greenhouse gas pollutants. Around the world, the momentum for carbon pricing is growing. More than 60 jurisdictions are now demonstrating climate ambition through the introduction of carbon prices (World Bank, 2020). However, significant disparities in price and emissions coverage dilute the policy's efficacy. Attention is now turning to alternative ways of dealing with the asymmetry of carbon prices across jurisdictions (or where no carbon price exists at all), to mitigate any potential loss of competitiveness; this is occurring, for example, in the EU, where border carbon adjustments (BCAs) are being considered as a mechanism that would not only address carbon leakage and competitiveness concerns, but also leverage other countries' participation in climate agreements.

For economies that are yet to enact ambitious climate policy, or those that desire decarbonisation but are undecided about the appropriate policy pathway – such as Taiwan – the potential introduction of such measures may be the start of a global regime where trade relations are affected by climate ambition. This suggests that carbon pricing policy should be a near-term priority.

Structure of the report

- **Section 2 outlines Taiwan's context in more detail,** considering its economic profile, energy system, emissions trends, the broader policy environment, and public attitudes to climate policy.
- **Section 3 makes the case for carbon pricing in Taiwan,** considering the underlying policy rationale for pricing carbon pollution, the broader set of benefits that carbon pricing provides, and the relative benefits of carbon levies and emissions trading systems.
- **Section 4 discusses the options for implementing carbon pricing.** It identifies key considerations for deciding on the appropriate carbon pricing instrument, the viability of different design options, the key advantages and limitations of our proposed approach, and the long-run drivers of Taiwan's climate policy development.
- **Section 5 concludes and sets out our recommendations for next steps.**

2. Taiwan's context

Headline points

- Almost all manufacturing industries in Taiwan are trade-exposed, and some are also emissions-intensive, such as basic chemicals and metals.
- Emissions-intensive and trade-exposed (EITE) industries represent about 38 per cent of manufacturing gross value-add and employ 970,000 people.
- The energy transition requires a significant shift away from fossil fuels, which supply 92 per cent of primary energy and are almost entirely imported. The remaining primary energy supply comes from nuclear (6 per cent) and renewables (2 per cent).
- Carbon dioxide emissions represent 95 per cent of greenhouse gas emissions. Growth in emissions between 2010 and 2017 was driven by rising electricity use and road transport.
- The electricity sector emits 59 per cent of Taiwan's carbon dioxide emissions.
- Coal-fired power generation made up 48 per cent of the generation mix in 2018 and gas-fired 34 per cent, compared with just 6 per cent for renewables.
- Public support for stronger climate action and the introduction of carbon pricing is growing and the business community has been open to the potential introduction of carbon pricing.

As a small, export-oriented economy that imports fossil fuels for most of its energy demand, Taiwan faces a range of challenges in reaching its target of lowering its greenhouse gas emissions by 50 per cent compared with 2005 levels by 2050, let alone the more ambitious emissions reductions targets needed to align with global ambitions under the Paris Agreement. Carbon pricing can play a major role in delivering these emission reductions while addressing these challenges. However, for carbon pricing to function successfully, it needs to be introduced in a way that is firmly grounded in an understanding of Taiwan's unique context.

This section outlines Taiwan's context and identifies key issues that would affect the operation of carbon pricing and its political feasibility, technical viability and potential economic implications. Taiwan's economic profile (Section 2.1), energy system (Section 2.2), emissions trends (Section 2.3) and institutional landscape (Section 2.4) should be considered in detail. Further, public attitudes to climate policy (Section 2.5) can play an important role in the choice of carbon pricing instrument (CPI) and its longer term success.

2.1 Economic profile

Taiwan has a service-based economy built around capital- and technology-intensive industries. Services make up 61 per cent of the economy, followed by 37 per cent from industry and 1 per cent from agriculture.[1] Geographically, there is a concentration of commercial services and consumer power around Taipei in the North, where half of Taiwan's 24 million population resides as well as Taichung and Kaohsiung on the west coast. By contrast, manufacturing activity is concentrated in Central Taiwan and Southern Taiwan, where the population density is lower.

Taiwan is tightly integrated within the global economy. It plays a critical role in technology supply chains by exporting semiconductors, electronics and communications equipment.

[1] Gross Domestic Product by Kind of Activity (Chained 2016 Dollars) from Taiwan's National Accounts 2019, National Statistics.

Growth in these sectors has underpinned wider economic growth, which averaged 2.4 per cent per year between 2015 and 2019 (National Accounts, 2019). Historically, inflation and unemployment have remained low, but the COVID-19 pandemic and geopolitical factors could put its trade-dependent economy under pressure in the near to medium term.

The manufacturing sector is an important stakeholder to consider when implementing a carbon price, being directly responsible or an indirect source for more than half of Taiwan's emissions. About 75 per cent of manufacturing gross value added (GVA) and 65 per cent of employment relates to the production of electronic components, petrochemical and coal products, and metals. Almost all of Taiwan's manufacturing is trade-exposed and competes on international markets.[2] This is different to many jurisdictions that have implemented carbon pricing where some manufacturing subsectors may be more reliant on domestic markets. The detailed composition of industry in Taiwan is presented in Table 2.1.

Table 2.1. Characteristics of industry in Taiwan (based on 2016 data)

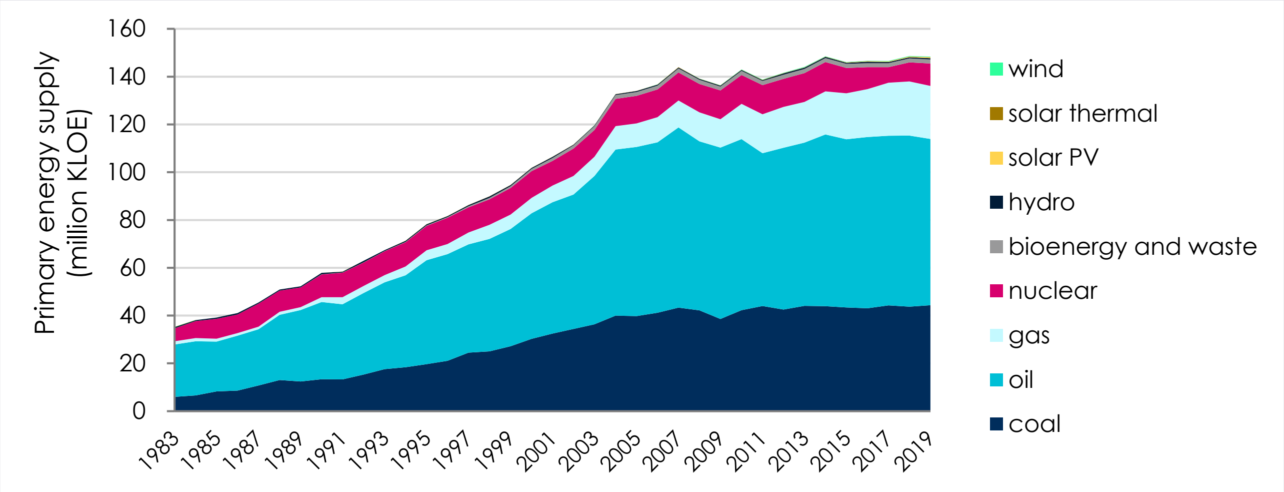
Industry	**GVA** (bn NT$)	**Persons employed**	**GVA per person** (m NT$)	**Annual growth rate**	**Export as % of demand**	**Import as % of supply**	**Electricity as % of costs**
Mining and Quarrying	11	3,703	2.97	NA	3.1%	**89.7%**	0.9%
Food Products and Prepared Animal Feeds	137	146,254	0.94	6.3%	6.0%	14.9%	1.5%
Beverages and Tobacco Products	92	18,833	**4.89**	4.8%	6.4%	16.6%	2.2%
Textiles	109	103,299	1.06	1.9%	43.6%	11.5%	3.3%
Wearing Apparel and Clothing Accessories	38	48,201	0.79	4.5%	30.2%	24.2%	0.9%
Leather, Fur and Related Products	18	20,089	0.9	-0.2%	19.3%	35.7%	1.2%
Wood and of Products of Wood and Bamboo	12	18,092	0.66	4.1%	4.3%	28.6%	1.5%
Paper and Paper Products	53	51,111	1.04	3.8%	13.2%	20.0%	3.8%
Printing and Reproduction of Recorded Media	45	55,394	0.81	1.4%	4.0%	3.0%	2.4%
Petroleum and Coal Products	196	22,054	**8.89**	**19.7%**	26.9%	27.7%	5.2%
Chemical Materials	**376**	94,723	3.97	-2.8%	31.0%	25.9%	4.8%
Other Chemical Products	89	55,316	1.61	8.8%	19.6%	34.1%	2.4%
Pharmaceuticals & Medicinal Chemical Products	47	31,812	1.48	7.7%	8.1%	27.4%	1.3%
Rubber Products	47	40,806	1.15	5.6%	34.4%	13.8%	2.8%
Plastics Products	139	139,181	1.00	5.6%	32.1%	18.5%	3.2%
Other Non-metallic Mineral Products	120	74,454	1.61	-4.8%	11.8%	21.0%	**5.9%**
Basic Metals	278	110,387	2.52	1.5%	18.4%	24.6%	3.1%
Fabricated Metal Products	341	**375,190**	0.91	5.3%	33.0%	15.7%	1.8%
Electronic Parts and Components	**2,053**	**609,058**	**3.37**	11.8%	53.0%	30.2%	2.3%
Computers, Electronic and Optical Products	**638**	220,519	2.89	6.5%	**70.4%**	21.0%	0.4%
Electrical Equipment	166	119,645	1.39	0.9%	30.6%	27.8%	0.8%
Machinery and Equipment	267	263,974	1.01	4.3%	30.4%	40.6%	1.0%
Motor Vehicles and Parts	152	101,515	1.5	5.2%	21.6%	22.5%	1.1%
Other Transport Equipment and Parts	96	78,153	1.23	4.0%	35.2%	27.3%	0.8%
Furniture	21	30,253	0.69	6.8%	37.8%	16.1%	0.9%
Other Manufacturing	124	81,546	1.52	6.4%	32.6%	20.3%	1.2%
Note: Bold denotes large values. Source: Industry and Service Census, Prinicipal Figures from National Accounts, input output tables							

2 Using a rule of thumb by regarding industries with exports and/or imports representing 10% or more of total sales as trade-exposed industries.

2.2 Energy system

Taiwan's energy supply is heavily dependent on imported fossil fuels. In 2019, Taiwan's primary energy supply reached 1,477 TWh (148.4 million kilolitres of oil equivalent/KLOE), of which 98 per cent was imported.[3] Most of its primary energy supply consists of oil and petroleum products (47 per cent), followed by coal (30 per cent) and natural gas (15 per cent). Almost all of these fossil fuels are imported. Nuclear contributes 6 per cent of the primary energy supply but is being phased out in line with the Government's plan to eliminate nuclear power by 2025. The domestic production of renewable energy contributes less than 2 per cent to primary energy supply (with renewables including bioenergy and waste, hydroelectricity, solar and wind).

Figure 2.1. Primary energy supply in Taiwan by source, 1983 to 2019



Source: Bureau of Energy (2019a, 2019b)

Final energy consumption rose by only 0.6 per cent per year on average between 1983 and 2019, despite economic growth at an average rate of 4 per cent.

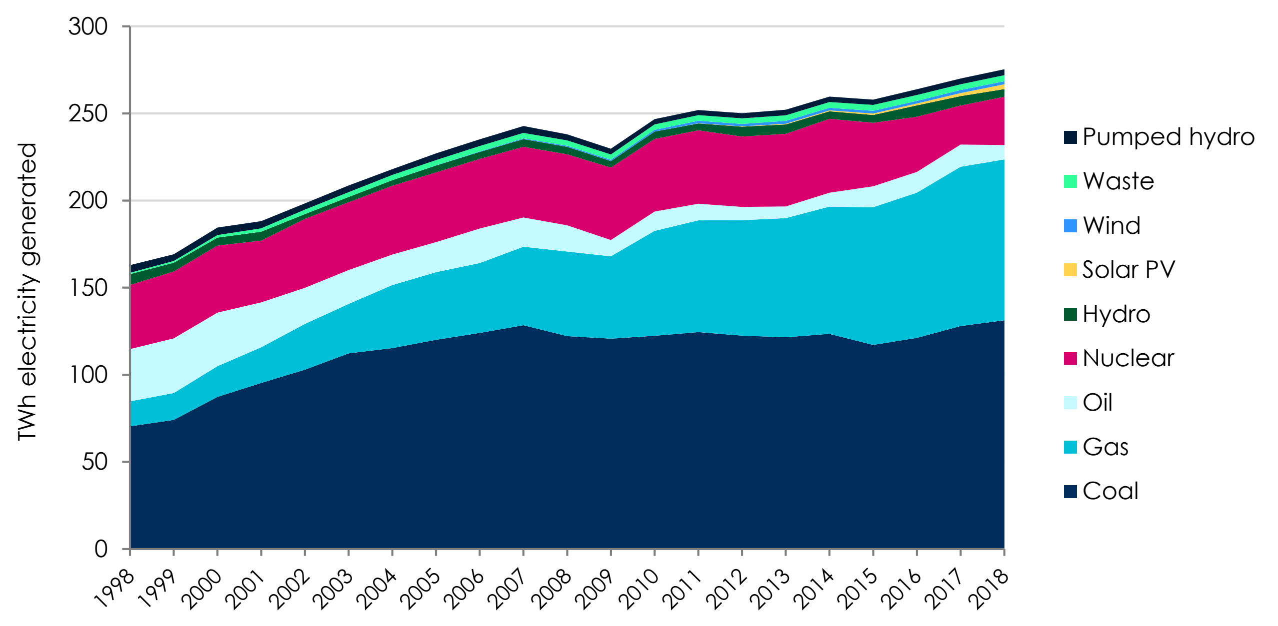
Excluding non-energy use, industry represents almost half of final energy consumption in Taiwan. This is followed by transport (25 per cent), services (12 per cent) and residential use (11 per cent). The reduction in energy intensity is driven primarily by the shift towards less energy-intensive economic activity. Improvements in energy efficiency in industry and buildings have also slowed down the growth in electricity demand.

Decarbonising the electricity sector would involve reducing coal-fired power and relying more on natural gas and renewables. As shown in Figure 2.2, Taiwan's generation mix depended on coal, oil and nuclear in the late 1990s. Gas-fired generation has risen significantly since the early 2000s to match the growing demand for electricity. By 2018, coal and gas contributed 48 per cent and 34 per cent of electricity generated, respectively. Nuclear contributed 10 per cent but the Government has committed to phasing it out completely by 2025.

Only 6 per cent of electricity generated in 2018 came from renewable energy, of which 49 per cent was hydroelectricity, 23 per cent waste and bioenergy, 17 per cent solar PV, and 11 per cent wind. In the 2019 amendment to the Renewable Energy Development Act, the Government adopted a target of having a 20:30:50 split between renewables, coal and gas in the generation mix by 2025. This would require rapid acceleration in the deployment of wind and solar PV.

[3] Energy Supply and Demand Situation of Taiwan published by the Bureau of Energy.

Figure 2.2. Electricity generation mix in Taiwan, 1998–2018



Source: Energy Statistical Annual Report 2019, Bureau of Energy

The electricity market is dominated by Taipower, a vertically integrated public utility. Taipower generates over 70 per cent of electricity in Taiwan and is the sole company responsible for transmitting and distributing electricity. The remainder of Taiwan's electricity is generated by nine independent power plants, 49 cogeneration operators, and individual renewable energy developers. They enter into power purchase agreements with Taipower, which acts as the off taker. The market is being liberalised under the Electricity Act Amendment in 2017 (for more details see Section 2.4).

Retail electricity prices are set by the Government. However, the electricity price has been set at below-cost levels in recent years, which has resulted in significant losses for Taipower, whose electricity business suffered NT$14 billion (US$479m) in losses in 2018 and an additional NT$10 billion (US$342m) in the first two months of 2019 alone (Feigenbaum and Hou, 2020). Implementing carbon pricing without the ability to pass through these costs could exacerbate losses to Taipower. The sustainability of this pricing model will hinge on future declines in fuel costs as Taipower's debt burden continues to increase.

2.3 Emissions – trends and abatement

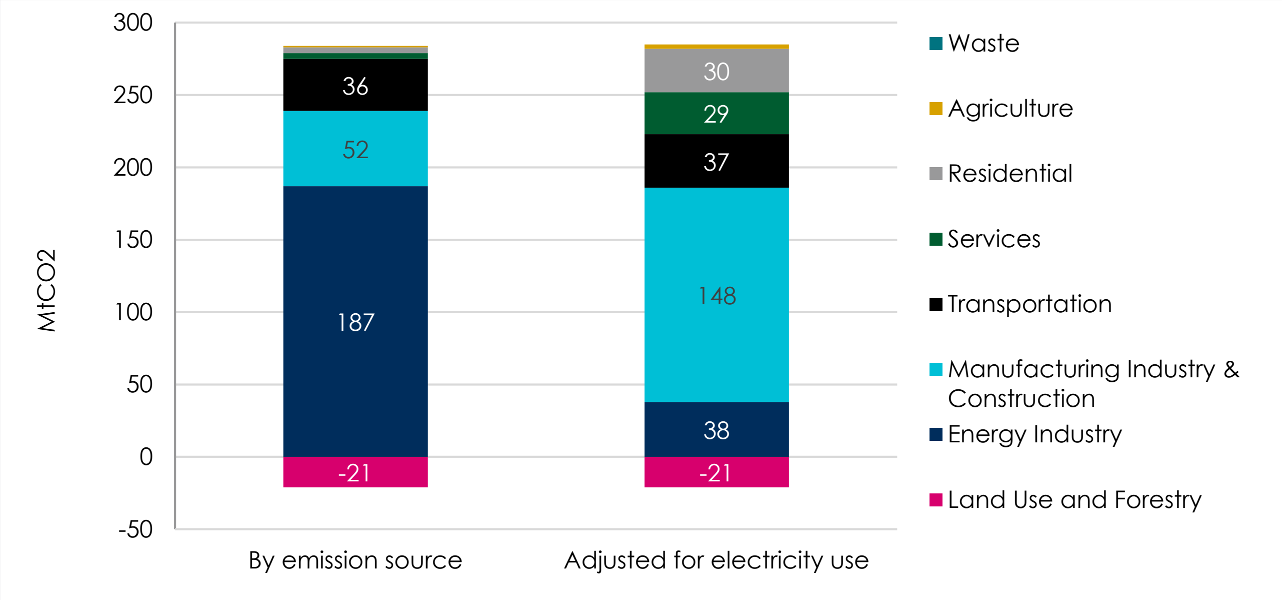
2.3.1 Recent history

In 2017, Taiwan was responsible for greenhouse gas emissions of 299 $MtCO_2e$. Total carbon dioxide emissions were 285 $MtCO_2$ (95.4 per cent of greenhouse gas emissions), followed by methane (1.9 per cent), nitrous oxide (1.6 per cent) and other greenhouse gases. The land use and forestry sector sequesters over 21 $MtCO_2$ per year, resulting in net greenhouse gas emissions of 277 $MtCO_2e$ in 2017.[4]

The sectoral breakdown of Taiwan's carbon dioxide emissions reflects the industrial base structure of its economy. Fifty-nine per cent of carbon dioxide emissions come from power generation, which can then be distributed to other end use sectors, as shown in Figure 2.3.

[4] 2019 National Greenhouse Gas Inventory Report.

Figure 2.3. Carbon dioxide emissions in Taiwan by sector in 2017



Source: 2019 National Greenhouse Gas Inventory Report and adjustment by the EPA for electricity use

After attributing electricity use to each end use sector (right-hand bar in Figure 2.3), 52 per cent of total carbon dioxide emissions come from manufacturing industry and construction, followed by the energy industry (13 per cent), transportation (13 per cent), residential (10 per cent), services (10 per cent), agriculture (1 per cent), and waste (1 per cent).[5] Emissions are also concentrated among a small number of large entities, after accounting for indirect emissions in electricity use. Within the industrial sector, the biggest 30 emitters account for 80 per cent of emissions.

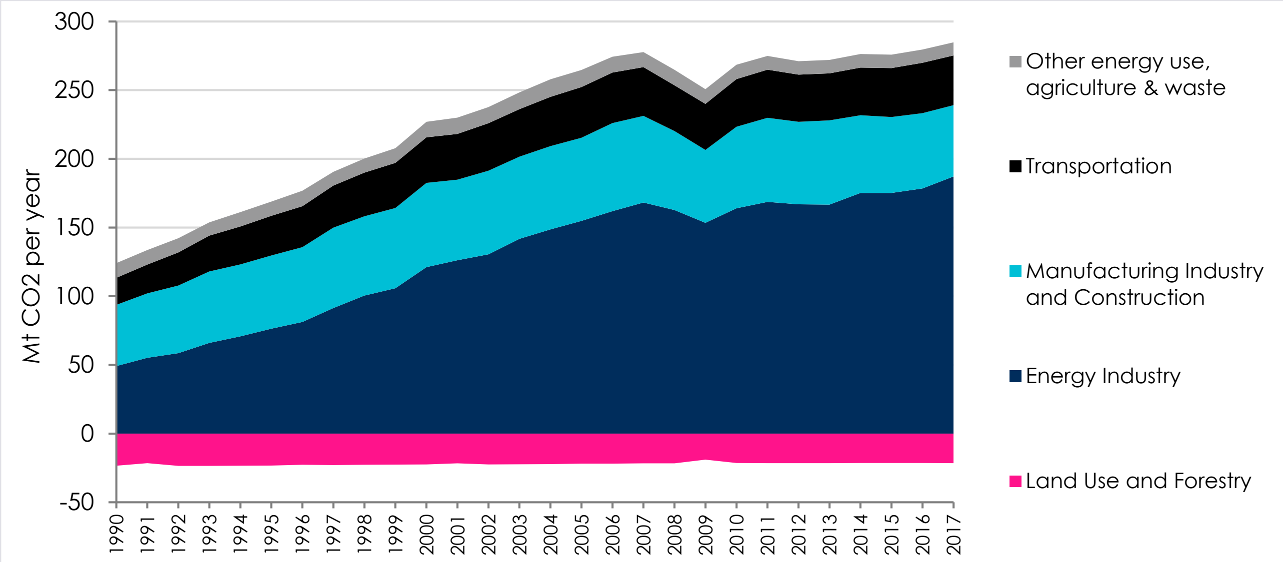
Carbon dioxide emissions from Taiwan have been growing steadily at around 1 per cent a year on average over the last 10 years, driven by rising electricity use and an increase in road transport. According to the latest data, from 2017, electricity generation constitutes 59 per cent of total carbon dioxide emissions and grew at an average rate of 5 per cent a year between 2014 and 2017.[6] This has been driven by growing electricity demand but has also accelerated because of the decommissioning of nuclear plants, resulting in a higher share of coal- and gas-fired power generation in recent years. The remaining growth in emissions is almost entirely due to road transport, which grew at an average rate of 1.5 per cent between 2014 and 2017. Emissions from other major sectors have remained mostly stable for the past two decades, and many have seen a slight decline in recent years.

Trends in Taiwan's carbon dioxide emissions are shown in Figure 2.4. A detailed breakdown of carbon emissions from the latest greenhouse gas inventory is available in Appendix 1.

[5] This is based on an article by the Taiwan EPA that attributed emissions to each end use sector after accounting for electricity consumption. Emissions from the energy industry represent own-use (e.g. power plants), activities from refineries and production of solid fuels.

[6] 2019 National Greenhouse Gas Inventory Report.

Figure 2.4. Trends in carbon dioxide emissions in Taiwan by source, 1990–2017



Note: Energy industry includes the production of electricity and heat, and refineries.
Source: 2019 National Greenhouse Gas Inventory Report

2.3.2 Abatement opportunities

The Government does not produce long-run emissions projections, but 2021–25 emission targets are being developed to reflect the estimated mitigation potential in each sector. Table 2.2. summarises the key abatement opportunities for each major sector. Agriculture and waste are not included because they each contribute just 1 per cent of Taiwan's total greenhouse gas emissions. The major mitigation options are in electricity generation and manufacturing, both of which include relatively sophisticated participants in international commodity and industrial markets, suggesting a price incentive may be an effective tool.

Table 2.2. Review of abatement opportunities in Taiwan, as identified in the literature

Sector	Abatement opportunities in Taiwan
Energy	Reduce coal-fired power generation, substituting it with renewables such as PV and wind. In the short term, gas-fired power generation would remain important to provide baseload power and to ensure grid stability given intermittent renewable energy. In the longer term, energy storage infrastructure will be needed to integrate renewables.
Manufacturing	For industrial heating, key options including electrification and energy efficiency improvements such as process optimisation and improved cooling systems can be adopted at production sites. Carbon capture and storage would be required for abating some process emissions and to produce hydrogen using natural gas, but this would first require significant investment in transport and storage infrastructure.
Transport	Increase the share of public transport and electric vehicles while lowering the emissions of the electricity that powers them, supported by the rollout of charging infrastructure.
Residential and services	Increase energy efficiency, thereby reducing electricity consumption.

Source: Authors, based on the 2018 National Communications of the Republic of China (Taiwan) under the UNFCCC, Greenhouse Gas Emissions Control Action Programs published by the Government, and Feigenbaum and Hou (2020)

2.3.3 Challenges for abatement in the electricity and manufacturing sectors

The main challenge in decarbonising the electricity sector, which directly accounts for 59 per cent of Taiwan's carbon dioxide emissions, is the difficulty of deploying variable renewable energy on the island. According to Taipower data, onshore wind and solar PV only have a capacity factor of 30 per cent and 15 per cent respectively.[7] A low capacity factor implies higher costs of renewable electricity and a greater need for baseload power and energy storage capacity to balance the grid. The ability to buy and sell electricity from other locations via interconnectors could alleviate this problem, but Taiwan does not have this option because it operates on an isolated electricity grid. This makes decarbonisation more expensive than in other geographies – such as Europe, where the use of carbon pricing alongside appropriate regulations has helped reduce electricity sector emissions significantly in recent years (see Box 2.1).

As for the manufacturing sector, any mitigation policy that follows the polluter pays principle may disproportionately affect the emissions-intensive and trade-exposed (EITE) industries. Being exposed to foreign trade means that firms facing additional costs from a carbon price might lose out to foreign competition or relocate to other jurisdictions to avoid the costs, creating what is called 'carbon leakage'. While almost all manufacturing sectors in Taiwan are trade-exposed, only a subset of them are emissions-intensive and will bear greater economic impact from a carbon price if leakage mitigation measures are not considered. The Chung-Hua Institution for Economic Research (CIER) independent think tank is currently conducting a detailed assessment of the potential impact of carbon pricing on various industries, and will better identify the precise scale of EITE sectors in Taiwan. A preliminary classification indicates that EITE industries represent at least 38 per cent of the gross value-add from the manufacturing sector and employ at least 970,000 people.[8]

Box 2.1. Reduction of electricity sector emissions in the UK and European Union

Evidence from electricity sector decarbonisation in the UK and EU – where significant emissions reductions have taken place over the last five years – suggests this can be achieved with a relatively modest carbon price alongside an appropriate mix of regulations, taxes and subsidies.

For example, in the UK, since 2012 coal generation has fallen by over 80 per cent, driven by the introduction of the Carbon Price Support in 2013 alongside policies such as Contracts for Differences (CfDs) to bring down costs of cleaner renewable alternatives (Sandbag, 2016). The UK's experience also suggests that it is easier to decarbonise the electricity sector than it is to bring down emissions from industry or transport.

However, unlike European countries, Taiwan operates on an isolated electricity grid and might therefore find it more difficult to integrate variable renewable energy.

2.4 Climate and energy policy

Carbon pricing does not operate in isolation – it must be designed to complement the broader mix of climate and energy policies to be effective. In this section we review the policy and institutional landscape in Taiwan and identify potential interactions with a carbon price, now and in the future.

Taiwan's overall response to climate change is set out in the Greenhouse Gas Reduction and Management Act (referred to as the GHG Act) in July 2015. This landmark legislation followed a long period of planning that dates from 1998, when the EPA first began inter-departmental

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7 Data available at Taipower website.

8 Based on 'high risk' sectors identified from the preliminary carbon leakage risk assessment by the CIER, which adapts the classification matrix of emissions intensity and trade intensity developed by the California Air Resources Board.

collaboration and consultation on the topic. With momentum from the agreement of the Kyoto Protocol in 2005, the EPA submitted a draft of the GHG Act to the legislature in 2006. This was met with strong opposition from industry due to concerns about the economic impact of carbon pricing and scepticism regarding the science of climate change. Conversely, environmental groups viewed the draft act as insufficient, and wanted the Government to commit to an emission reductions target and to limit its reliance on nuclear power.[9] These disagreements stalled the introduction of carbon pricing and it was not until 2015 that bipartisan support for strong climate action led to the passage of the GHG Act.

The GHG Act sets out an explicit target of keeping 2050 greenhouse gas emissions below 50 per cent of 2005 levels. Under the Act, the Government is mandated to set phased targets for greenhouse gas emissions in successive five-year periods (EPA, 2015):

- The Phase 1 (2016–2020) target was set at reducing emissions to 2 per cent below the 2005 level by 2020.
- A preliminary target was set for Phase 2 (2021–2025) at 10 per cent below 2005 by 2020.
- A preliminary target was set for Phase 3 (2026–2030) at 20 per cent below 2005 by 2030.

The GHG Act also established a framework for reducing emissions in Taiwan, including the provision for the EPA to implement an emissions trading system (ETS) and impose mandatory greenhouse gas emissions report regulations. Currently, over 290 companies are reporting their direct and indirect emissions under this mandatory arrangement. However, successive governments have been unable to agree on an approach or implementation schedule for a carbon pricing instrument.

The EPA is the main organisation responsible for developing, implementing and overseeing the operation of the carbon price. Although the EPA is a large organisation, only a small team within the department is responsible for carbon pricing policy and it is likely that the introduction of carbon pricing would likely require additional capabilities and resources to ensure effective management. This is particularly the case for the introduction of an emissions trading system, which requires more complex administrative and regulatory facilities to function effectively. The EPA is expected to propose an amendment to the Act in late 2020, which could allow the use of a carbon levy as a complement to an ETS.

2.4.1 Liberalisation and mitigation plans in six sectors

In 2018, the Government announced action plans for mitigation across all major sectors. The plans were developed under six categories: energy, manufacturing, transport, residential and commercial buildings, agriculture, and environment management (EPA, 2019b). While the EPA is the government agency responsible for climate policy in Taiwan, energy policy is overseen by the Ministry of Economic Affairs and sectoral mitigation priorities are directed by respective government ministries.[10]

Important elements of the plans for these six sectors are as follows:

- **Energy:** Ongoing reforms to the electricity sector aim to liberalise the market and facilitate the integration of renewables into the generation mix. Under the Electricity Act Amendment in 2017, the electricity sector will be gradually liberalised with private sector involvement, and power generators will no longer be considered public utilities.[11] Since emissions from public utilities are currently excluded from carbon pricing plans under the GHG Act, these generators could be covered by carbon pricing after market liberalisation or an amendment to the GHG Act. By 2025, the Government aims to have 20 per cent of electricity generated from renewable energy, 30 per cent from coal, and 50 per cent from

[9] Based on report from the Environmental Information Centre (2015).

[10] The Ministry of Economic Affairs leads on sectoral mitigation in energy and manufacturing; the Ministry of Transportation and Communications leads on transport; the Ministry of the Interior leads on buildings; the Council of Agriculture leads on agriculture; and the EPA leads on environmental management.

[11] According to the amended Electricity Act in 2017, which introduces new business models for renewables in the first phase and restructures Taipower in the second phase, likely between 2023 and 2026.

gas, eliminating the use of nuclear power.[12] To support renewables, for the last decade Taiwan has primarily relied on a feed-in-tariff (FiT), which was available to technologies such as PV, wind, small hydro and biomass. A voluntary renewable energy certificate (RECs) scheme was also put in place but as most holders of RECs are saving them for their own use, there have been very few transactions and therefore the scheme has had limited impact.

- **Manufacturing:** The manufacturing sector has been a major focus for policy due to its significant energy use and carbon emissions. In the action plan for manufacturing sectors the Government stated its aim to lower the sector's carbon intensity by 43 per cent in 2020 compared with the 2005 level. The Ministry of Economic Affairs projected that this target will be met in either 2019 or 2020.[13] Policy measures have included subsidies for boilers and factories to use low-carbon fuel, incentives for process improvement and replacement of old equipment, promoting technical assistance for energy management, and promoting sustainable production processes through environmental footprint disclosure.
- **Transport:** In the transport sector policy measures have focused on promoting public transport and electric vehicles. In line with the action plan for the transport sector, subsidies have been provided to local governments to promote the use of public transport and support the rollout of electric vehicle charging infrastructure. Measures to support the uptake of electric vehicles have proven popular, with an annual budget of NT$400 million for subsidising the purchases of electric vehicles exhausted in the first four months of 2019.[14]
- **Residential and commercial buildings:** Enforcement of minimum energy efficiency standards has been strengthened for new commercial and residential buildings. Under the action plan for residential and commercial sectors, the Government aimed to increase basic energy efficiency design standards for outer shells of new buildings by 10 per cent by 2020 from the 2016 level. To complement the new standards, the Government is also promoting energy audits and subsidising upgrades to existing buildings.
- **Agriculture:** The Council of Agriculture has provided technical assistance to encourage eco-friendly farming and the reuse of biogas at farms. It has also strengthened incentives for afforestation and forest management.
- **Environment management:** New regulations focus on reducing the use of plastics in the retail and hospitality sectors. The Government is also improving the monitoring and verification systems for waste and helping municipalities explore technical options to reuse biogas.

Box 2.2. Relevant legislation and policy documents

- 2015, July: Greenhouse Gas Reduction and Management Act (溫室氣體減量及管理法)
- 2017, January: Amendment to the Electricity Act (電業法)
- 2017, February: National Climate Change Action Guidelines (國家因應氣候變遷行動綱領)
- 2018, March: Greenhouse Gas Reduction Action Plan (溫室氣體減量推動方案)
- 2018, October: Greenhouse Gas Emissions Control Action Programs for six sectors (部門溫室氣體排放管制行動方案)
- 2019: Implementation plans from all 22 municipalities (溫室氣體管制執行方案)
- 2019, May: Amendment to the Renewable Energy Development Act (再生能源發展條例)

[12] This target is set out in the 2019 amendment to the Renewable Energy Development Act (Ministry of Economic Affairs, 2019).

[13] Based on the 2019 report on outcomes against the action plan.

[14] Based on news interview with the Government, reported from Apple Daily.

Understanding policy interactions is essential to developing a coherent policy mix. The potential interactions of existing policies with carbon pricing are summarised in Table 2.3.

Table 2.3. Policy interactions

Sector	Aspect of policy landscape	Interaction with carbon pricing
Electricity	Ongoing market liberalisation but continued regulation on retail electricity prices	• Under the current GHG Act Taipower can only be included under carbon pricing if it is no longer a public utility – the 2017 amendment to the Electricity Act would enable this, likely before 2026. • Depending on the eventual regulatory structure, the carbon price may not be transmitted effectively to electricity prices. In this case, the utility company and/or power generators might bear most of the cost and there is no downstream incentive for reducing electricity demand. • If indirect subsidies for electricity remain in the new regulatory regime, they would counteract the incentives provided by the carbon price.
Industry	Subsidies for boilers and factories to use low-carbon fuel, process improvement and replacement of old equipment; technical assistance for energy management; enforcement of environmental footprint disclosure	• These policies mostly complement the use of carbon pricing because they provide extra support for expensive abatement technologies and address non-price barriers to adoption.
Transport	Subsidies by local governments to promote use of public transport and electric vehicles	• Overlaps with the incentives provided by a carbon price, but may be necessary if the carbon price is inadequate to spur adoption.
	Planning for EV charging infrastructure	• Complements carbon pricing by addressing non-price barriers to adoption.
Buildings (commercial and residential)	Increase basic energy efficiency design standards for outer shell of new buildings	• Overlaps with the incentives provided by a carbon price, but may be necessary if the carbon price is inadequate to spur adoption.
	Promote energy audits and technical assistance for existing buildings and energy efficiency labelling for equipment and appliances	• Complements carbon pricing by addressing non-price barriers to adoption.

Source: Authors

2.5 Public attitudes to climate policy

The growing urgency of climate change has raised public support for stronger climate action and the introduction of carbon pricing. In a survey completed in Taiwan in May 2020, 88 per cent of respondents supported a carbon levy on large emitters.[15] In an earlier survey, conducted in 2018, 67 per cent of respondents said they would be willing to bear higher electricity prices if that were necessary for integrating more renewables into the generation mix.[16] Respondents were willing, on average, to bear 13.2 per cent higher electricity prices. While it should be noted that the survey was conducted during a prolonged public debate around the construction of a new power plant and that it is not certain if this level of support would be reproduced today, the results suggest there is considerable room for implementing a carbon price: a carbon price of NT$300/t$CO_2$ (US$10/t$CO_2$) amounts to a cost equivalent to approximately 6 to 7 per cent of retail electricity prices.[17] This aligns with broader support for a clean energy transition. For instance, the 2018 survey also saw 58 per cent of respondents opposing the construction of a coal-fired power plant, though concerns were mainly directed against the issue of air quality rather than carbon emissions.

The success of a carbon price can be greatly improved by building businesses' capacity to participate and ensuring their early engagement to address concerns. This should be in concert with clear communication about the environmental, social and economic impacts of the carbon pricing instrument and how the proceeds are being used. In recent years the business community has begun to acknowledge the potential introduction of carbon pricing. Some firms have expressed an initial preference for a carbon levy given existing familiarity with environmental levies and the processes required. To assess the capacity of industry to effectively respond to carbon pricing options and the potential impacts of different design decisions, early stakeholder engagement should be conducted. This can help identify potential problems with different carbon pricing options and potential solutions, and it can help with the detailed design of the policy and processes needed to implement a carbon price.

[15] Survey by the Risk Society and Policy Research Center (RSPRC).

[16] More information from this media report from Vision magazine.

[17] Calculated using the average emissions intensity of electricity generated in Taiwan, which is approximately 0.5kg CO_2/kWh.

3. The case for carbon pricing in Taiwan and globally

Headline points

- Carbon pricing forms an essential part of the policy mix to mitigate greenhouse gas emissions.
- As a market-based instrument, carbon pricing can incentivise more cost-effective emissions reduction than traditional command-and-control regulatory standards.
- 64 jurisdictions globally now use or have scheduled the implementation of carbon pricing to achieve their climate commitments.
- A well-designed carbon pricing policy can be effective in reducing emissions while having no adverse impact on economic growth.
- Taiwan is likely to choose to implement either a carbon levy or an emissions trading system (ETS).
- Increasingly, jurisdictions are developing carbon pricing instruments that contain a mix of attributes of taxes and trading and can capture many of the benefits of both.
- In the short run, ease of administration and simplicity of policy design and implementation are often important factors in determining what type of carbon pricing instrument is feasible.
- In the long run, differences in the fundamental attributes of carbon levies and ETSs may determine the longer-run development of a carbon pricing policy.

Carbon pricing alone will not fully address the challenge of climate change, but it forms an essential part of any credible future policy mix for Taiwan, as it does for other economies. By putting a price on damaging climate pollution, carbon pricing seeks to internalise the costs of greenhouse gas emissions, and in so doing to incentivise emitters to take account of this pollution in their production and consumption decisions. Carbon pricing operates in a broader climate policy mix, and a range of other policies may be needed to tackle the non-price barriers to effective climate action.

Carbon pricing is now being used or scheduled for implementation in 64 jurisdictions globally, with more countries introducing carbon pricing every year. This reflects not only its role in reducing pollution, but also a range of other economic, social and environmental benefits that can come with the introduction of carbon pricing.

This section discusses the case for carbon pricing, starting from first principles, before explaining the key differences between carbon taxes/levies and emissions trading systems (ETSs).

3.1 Principles of carbon pricing

The central barrier to reducing emissions is that private actors do not face the full costs of their emissions. Climate change is a market failure, where emissions today lead to delayed widespread social, economic and environmental harm. In the absence of a mechanism by which to account for these damages, private market incentives mean that the costs of emissions are borne by neither businesses nor consumers.

Conventional approaches to environmental policy often employ command-and-control regulations to safeguard the environment. These standards are either technology- or performance-based. Performance-based standards are more flexible than technology-based standards, specifying allowable levels of pollution but leaving the specific methods of achieving those levels up to regulated entities.

Although command-and-control instruments have often featured more heavily than market-based instruments in environmental policy over the past four decades, they have major limitations. First, command-and-control regulations offer no incentive to improve the quality of the environment beyond the standard set by a law. Once the command-and-control regulation has been satisfied, polluters have zero incentive to do better. Second, command-and-control regulation is inflexible. It usually imposes uniform standards on all polluters. This means that it draws no distinctions between firms that would find it easy and inexpensive to meet the pollution standard or to reduce pollution even further and firms that might find it difficult and costly to meet the standard. Firms have no reason to rethink their production methods in fundamental ways that might reduce pollution even more and at lower cost.

As a market-based instrument, carbon pricing can incentivise more cost-effective emissions reductions. Carbon pricing is any policy that creates a direct price for the emission of carbon dioxide or other greenhouse gas pollutants. A government can implement this by setting a price of emissions (a carbon tax) and allow companies to determine how much to emit. Alternatively, a government can set the quantity of emissions (in an ETS) and allow the price of emissions to be determined through secondary market trading of emission allowances between companies. Either way, this encourages businesses and consumers to internalise incentives for emissions abatement. Firms will treat the carbon price like other business costs and respond by reducing their own emissions. Consumers will face higher prices and reduce their purchases.

Most importantly, carbon pricing is cost-effective when all actors face the same carbon price because, in theory, mitigation options with marginal abatement costs that are cheaper than the carbon price will be adopted while those that are more expensive will not be adopted. For this reason, many countries and sub-national jurisdictions use carbon pricing to help reduce greenhouse gas emissions and achieve their climate commitments.

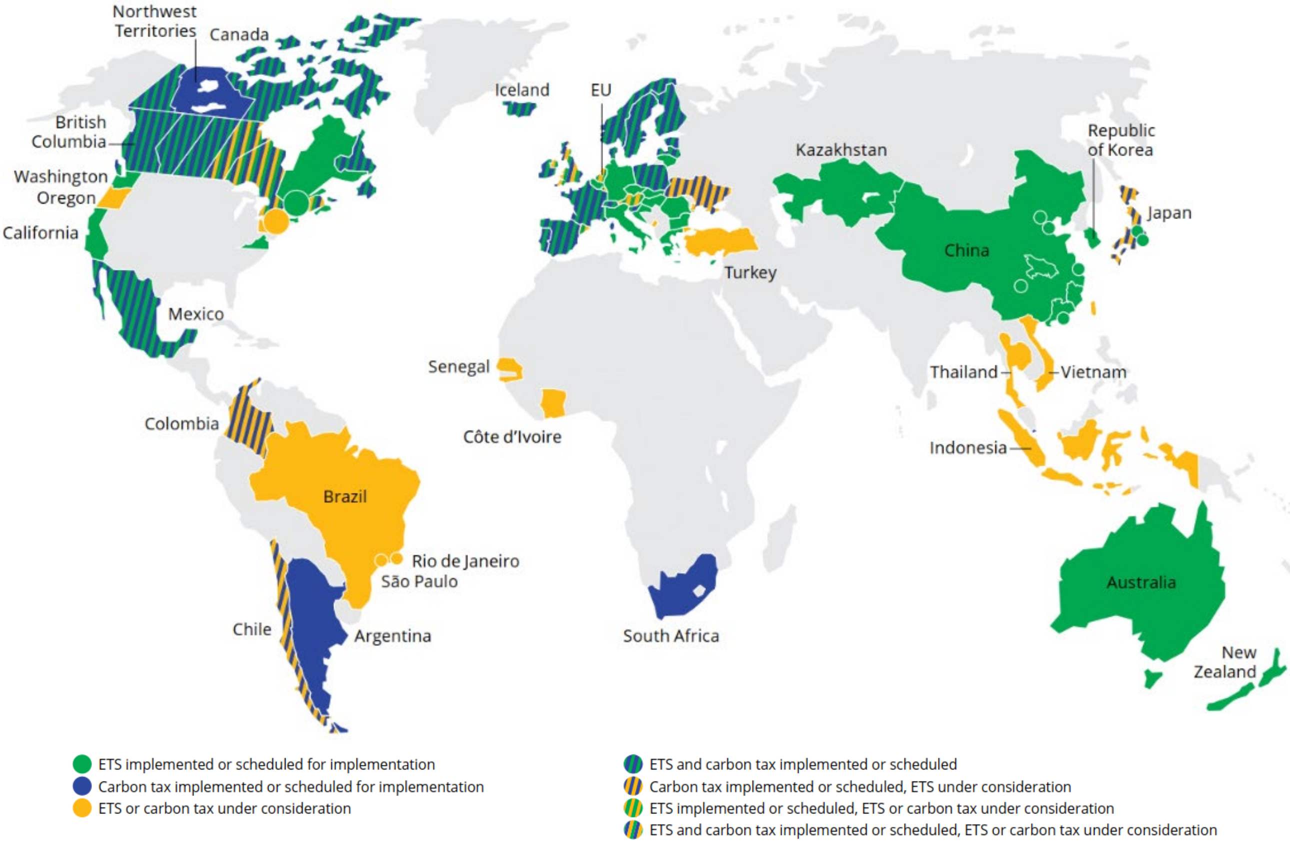
As discussed, there are currently 64 carbon pricing initiatives (in particular, carbon taxes and cap-and-trade programmes) in place or in the process of implementation; 10 were launched in 2019 alone.[18] These initiatives are spread globally, with South Africa becoming the first African country to price carbon, Singapore becoming the latest country in Asia to introduce a carbon tax, and Mexico's ETS paving the way for emissions trading in Latin America.

Figure 3.1 below shows the various jurisdictions where some form of carbon pricing is implemented, scheduled for implementation or under consideration.[19]

[18] Based on the World Bank's carbon pricing dashboard, as of October 2020.

[19] Jurisdictions' experiences of carbon pricing are discussed in detail in publications from the World Bank and the International Carbon Action Partnership (ICAP). The State and Trends of Carbon Pricing series published by the World Bank provides a high-level overview of carbon pricing initiatives across the world, while the ICAP Status Report series dives deeper into the policy developments in jurisdictions implementing ETSs. Various handbooks from ICAP also provide guidance on design features of an ETS.

Figure 3.1. Carbon pricing initiatives implemented, scheduled for implementation or under consideration



Note: The large circles represent cooperation initiatives on carbon pricing between subnational jurisdictions. The small circles represent carbon pricing initiatives in cities.

Source: World Bank (2020) (reproduced under Creative Commons Attribution 3.0 IGO licence)

Carbon pricing operates within a complex policy mix to complement other climate, energy and environmental policies. The price incentives introduced by carbon pricing do not address all the barriers to climate change mitigation. For instance, non-price barriers to mitigation or financial barriers to the deployment of expensive mitigation technologies cannot be addressed effectively by carbon pricing. A range of other policies are necessary to mobilise mitigation. For instance, some emerging clean technologies may be too expensive for an early-phase carbon price to unlock without raising concerns over distributional impacts (Burke et al., 2020). In these cases jurisdictions may seek to pursue other instruments, such as dedicated technology funds, low-carbon technology mandates, or research, development and deployment support to reduce technology costs. A variety of enabling policies are required to establish standards, mitigate risks and create the right market conditions.

With a range of policy options available to reduce emissions, jurisdictions have used carbon pricing to play different roles in their overall policy mix. Some jurisdictions, like New Zealand and British Columbia, have used carbon pricing as a central plank of emissions reduction policies. In other jurisdictions, like Singapore or California, it might serve as a backstop to increase the likelihood that emissions targets are met if other policy measures like emissions standards or public investments in low carbon technology prove less effective than hoped.

There is evidence that a well-designed carbon pricing policy can be effective in reducing emissions while having no adverse impact on economic growth. Globally, carbon pricing has been demonstrated to be a highly effective tool to reduce emissions without hampering economic growth. For example, Metcalf (2019) finds no adverse GDP impacts of the British Columbia carbon tax between 1990 and 2016 and in fact, when examining European countries over the period 1985 to 2017, a modest positive impact on GDP is found. Therefore, designed well, carbon pricing policy represents a powerful tool for Taiwan to incentivise cost-effective mitigation while growing its economy and at the same time playing its part in the international effort to combat climate change.

3.2 Carbon levy versus emissions trading system

Taiwan is likely to choose to implement either a carbon levy or an ETS.[20] In theory, these two carbon pricing instruments (CPIs) could achieve the exact same outcomes in a given time period if there is no uncertainty and the instruments are calibrated to produce the same carbon price. In practice, however, uncertainty regarding the future trajectory of emissions, the cost of mitigation, broader economic circumstances, political economy considerations and the ability to give away free allowances under an ETS mean that these instruments have important differences, which often dictate the choice between the two in the short and long run. These differences are:

- **A carbon levy directly sets a price on greenhouse gases.** Under a carbon levy, liable entities need to pay an amount proportional to the emissions in their business activities. They are therefore incentivised to reduce emissions by adopting production methods that are less emissions-intensive, such as implementing energy efficiency measures or investing in and fuel switching to low-carbon technologies. The environmental agency can determine the levy, but regulated entities control how much to emit.
- **An ETS allocates or sells a limited number of allowances for greenhouse gas emissions, requiring regulated entities to purchase the right to emit.**[21] The right to emit is commoditised in the form of emissions 'allowances', and regulated entities are required to surrender one allowance for each unit of emissions for which they are accountable.[22] Regulated entities acquire allowances from auctions, or, in most cases, they are allocated allowances for free. These allowances can then be traded with other regulated entities in a secondary market, creating a market price for emissions. The price on emissions thus provides a financial incentive for emissions reduction. Prices adjust until the demand for emissions allowances matches the supply, which is a cap determined by policymakers.

Since the carbon price is fixed by the government, the key advantage of a levy is it provides a predictable carbon price level convenient for forward planning and enables policymakers to estimate the revenue from the levy. Control over the price also allows policymakers to directly manage the strength of the price signal transmitted to regulated entities. By choosing an ambitious carbon pricing level or committing to raise the price in the future, policymakers can help boost investment in early-stage low-carbon technologies.

A carbon levy is also relatively simple to implement compared with an ETS. While any CPI requires a robust monitoring, reporting and verification (MRV) system, carbon levies are less prone to market manipulation if there are just a few large emitters, they are easier to implement as they do not require setting up a secondary market, and they can build on existing administrative infrastructure such as the air pollution control fee and water pollution fee.

It can be difficult to calibrate a carbon levy to deliver emissions reductions aligned with an emissions target. This is because it is often hard to predict the amount of emissions reductions for a given carbon price. Furthermore, as was the case in Australia, governments that inherit a levy from a more environmentally-committed predecessor can repeal or roll back the carbon

[20] We use the terminology 'carbon levy' in this report and it refers to the same idea as a carbon tax in the literature. However, a levy or fee is typically managed by the environmental agency (the EPA in Taiwan), while a tax is generally managed by the treasury.

[21] Baseline and credit systems are a subtype of ETS, using an emissions intensity-based cap set at either a firm or industry level and calculated net liabilities or credits based on some performance-based standard.

[22] One allowance typically equates to one tonne (1,000 kg) of carbon dioxide equivalent, or one short ton (907 kg) of carbon dioxide equivalent in some systems in the United States.

levy more easily, as regulated entities do not hold assets in the form of emissions allowances, as in the case of an ETS. In Taiwan these concerns could pose a challenge if the key objective for the carbon levy is to achieve Taiwan's emissions target.

If policymakers are concerned about the economic impact of a carbon price, both a carbon levy and an ETS allow for policy designs that shield industry from the financial impact:

- Policymakers can provide adequate compensation to businesses to mitigate risks of carbon leakage. For an ETS, the government could allocate free emissions allowances to regulated entities and still retain the price signal. This form of industry support is frequently implemented in ETSs around the world. In principle, an equivalent measure can be done for a carbon levy by offering levy-free credits to businesses.
- Domestic competitive distortions for industries with actors near the threshold for liability can be addressed, for example, by specifying that the first 25,000 tonnes of carbon emissions of a regulated entity are exempted from the carbon price.
- Complementary policies can also reduce the immediate costs of carbon pricing in industry while supporting long-term decarbonisation investment. For example, Singapore supports energy efficiency measures in industry through training programmes, grants and tax incentives in addition to providing a price signal through its carbon tax (National Climate Change Secretariat Prime Minister's Office, 2016).

An ETS can provide additional responsiveness and flexibility regarding when emissions reductions occur, which can lower the overall costs of mitigation compared with a carbon levy. The carbon price in an ETS tends to fall during recessions and rise during expansions because the price of emissions allowances is determined by market demand. This counter-cyclical price response reduces the costs of mitigation over time. Depending on the design of the ETS, entities may also be allowed to borrow allowances from future compliance periods, or bank surplus allowances for later use. This provides businesses with flexibility on when emissions reductions occur, letting them choose the timing of investment according to their needs. Furthermore, if Taiwan were to implement an ETS and link it with an international ETS, trading of emissions allowances could take place across borders, offering efficiency and risk sharing gains and geographical flexibility on the locations in which mitigation occurs.

However, a well-functioning ETS relies on having sufficient liquidity in the secondary market and mitigating market power. The lack of liquidity arises when there is a scarce supply of emissions allowances on the secondary market. This is more likely to occur when the number of market participants is small. Insufficient liquidity will lead to limited trading activity and inhibit price discovery in the secondary market, creating wider fluctuations in the price of allowances. Market power issues arise when a small number of large entities contribute to a majority of emissions under the scope of the ETS. They may be able to use their dominant position to distort auctions and hoard emissions allowances, manipulating the market price for allowances. Again this will prevent the smooth functioning of the ETS and make it less cost-effective.

It is possible to improve price predictability in an ETS using supply adjustment measures (SAMs) or price controls. SAMs adjust the supply of allowances into the market in response to certain criteria. This is generally done by either reducing supply if prices are too low, or increasing supply if prices are too high. By increasing price certainty, SAMs can help to provide bounds on future price expectations, which can support investment in low-carbon technologies and assets. By reducing the bounds of future price expectations, SAMs can reduce price risk, which may reduce the required rate of return for this investment and thus greater abatement investment. An alternative way to provide certainty in the price level is to adopt price floors and price ceilings in the auction of emissions allowances or more generally. These design characteristics reflect that increasingly, jurisdictions are developing CPIs that contain a mix of attributes of taxes and trading and can capture many of the benefits of both. This suggests the decision between these distinct CPIs often turns out to be a choice of design elements along a policy continuum (Stavins, 2019). Ensuring good design of carbon levies and ETSs in many ways can be more important than the choice between the two instruments.

Table 3.1 compares the key characteristics of a carbon levy and an ETS.

Table 3.1. General comparison of a carbon levy and an emissions trading system

Element	Carbon levy	Emissions trading system (ETS)
Price predictability	The carbon price is given by a pre-defined levy rate. This provides a stable price signal to inform investment decisions. It also makes calculating the compliance cost easier for regulated entities.	The carbon price is determined by the market. This automatically adjusts for economic conditions but might lead to price volatility.
Ease of administration and simplicity	The relative simplicity of a carbon levy and the ability to rely on existing tax infrastructure make it easier to implement in a wide range of sectors.	More complex to implement as it involves a secondary market for trading allowances. This requires additional capabilities from regulators and regulated entities, making it difficult to cover certain sectors with complex MRV (e.g. agriculture).
Certainty of emissions levels	Emissions reductions are determined by market dynamics and it can be difficult to align the levy rate to an emissions target.	Provides more certainty in emissions and can be aligned better to a certain policy targets (e.g. carbon budgets).
Flexibility and responsiveness	Carbon levy offers limited temporal flexibility (although it is possible to offer rebates and delay liabilities) for regulated entities and the price level does not respond to economic conditions unless the policymaker adjusts the carbon price level.	Temporal flexibility provisions of an ETS, such as banking and borrowing of allowances, can provide firms with the option to take advantage of mitigation options outside established compliance periods. The instrument is also responsive to economic conditions as market demand affects the price of allowances.
Risks that affect smooth functioning	A carbon levy carries fewer risks but predictable price escalation can be undermined without institutional safeguards.	An ETS only functions well in a competitive market environment with many participants. Risks with insufficient liquidity and concentration of market power are more pronounced in smaller jurisdictions.

Source: Authors

3.3 Considerations influencing the approach to carbon pricing

The section above has dealt mostly with the technical difference between CPIs. Conceptually, it is also helpful to distinguish short-run barriers (often political, legal and institutional factors) from long-run objectives (environmental outcomes, economic efficiency and competent policy administration) when evaluating the viability of CPIs.

In the short run, ease of administration and simplicity of policy design and implementation are often important factors in determining what type of CPI is feasible. It can take significant time to build the capacity needed to support effective carbon markets. In particular, policy design for an ETS has to address the challenges from illiquid or uncompetitive markets. In contrast, a carbon levy is comparatively simple and can often be implemented by simply building on systems established for existing energy and environmental taxes. When assessing these legal and institutional factors, introducing a carbon tax may appear the easier choice. However, political factors may make the introduction of certain types of policy infeasible. This is a particularly important issue for carbon taxes, given people's aversion to taxes generally, and to carbon taxes more specifically (Carratini et al., 2017). A thorough examination of what is politically possible may therefore lead policymakers to choose an instrument that looks comparatively worse on legal or institutional grounds but has far greater political feasibility, such as an ETS.

In the long run, differences in the fundamental attributes of carbon levies and ETSs may determine the development of a carbon pricing policy. This means that understanding the fundamental objectives of a jurisdiction in introducing carbon pricing should influence its longer-term development. The priority given to each policy objective and weighting given to each driver could influence the preference for either an ETS or a carbon tax (Table 3.2).

Table 3.2. Considering objectives and potential preference for an emissions trading system or a carbon levy

Objective and role of carbon price	Considerations	Potential preference
Achieving emissions targets Carbon pricing can be strengthened over time by tightening caps and increasing price levels.	An ETS can guarantee that the jurisdiction limits emissions to a pre-defined level. However, the environmental integrity of both instruments should be considered; a relatively ambitious carbon levy could still deliver more emissions reductions than an ETS with a cap that is not tight enough and that allocates too many (free) allowances.	ETS
Cost-effectiveness Carbon pricing encourages businesses and consumers to reduce their emissions in the most cost-effective way possible.	The temporal flexibility and responsiveness of an ETS can reduce the costs of mitigation over the longer term. However, the administrative costs could be higher for an ETS. Crediting mechanisms can be used under both a carbon levy and an ETS to help incentivise mitigation in sectors that are hard to cover under the carbon pricing instrument, such as agriculture and forestry.	ETS
Underpinning low-carbon investment Carbon pricing increases the cost of carbon-intensive technologies, providing financial incentives to invest in low-carbon technologies.	Low-carbon investment is best mobilised through a high, increasing and stable carbon price. A carbon levy can give policymakers direct control over the carbon price, thus allowing them to choose the strength of the price signal. Policymakers also control the strength of the price signal in an ETS, but this is done indirectly through adjusting the amount of allowances in the market or using hybrid elements such as supply adjustment measures.	Carbon levy, or ETS that ensures a minimum price
Raising revenue Carbon pricing can help raise revenues.	A carbon levy may offer a more predictable source of revenue as the carbon price is set by policymakers.	Carbon levy
Generating co-benefits Carbon pricing produces other local benefits such as improved air quality, employment and technological innovation.	Both an ETS and a carbon levy can deliver these local co-benefits. However, policymakers concerned with maximising these local benefits might want to limit the use of international offset credits that may result in these co-benefits shifting abroad.	Neutral
International cooperation Trading of mitigation outcomes across jurisdictions can enhance cost efficiency and strengthen political and economic links.	Thus far, jurisdictions have achieved this international cooperation via ETSs and crediting mechanisms. This contributes to increasing cost-effectiveness of carbon pricing instruments by allowing emissions reductions to take place in jurisdictions that find it more economically viable to do so.	ETS

Source: Authors

4. Assessing carbon pricing options for Taiwan

Headline points

- There are risks in Taiwan from concentrated market power and insufficient liquidity in an ETS that need to be considered.
- To implement an ETS, the Government would need to develop market regulation and trading infrastructure for the secondary market.
- We recommend that the implementation of carbon pricing begin with a carbon levy that covers large emitters in manufacturing and, if possible, electricity generation.
- Analysis of the Taiwanese context suggests that in the short run a carbon levy may be the most feasible option but in the long run Taiwan could choose to utilise either a levy or an ETS.
- We recommend starting the levy at a low level with a clear trajectory to increase it to the level required to meet the Paris Agreement goals.
- The levy can be designed in a manner that can facilitate a transition to an ETS once the required capacity is developed and industry is more familiar with the system.

Carbon pricing can play a crucial role in helping Taiwan meet its 2050 emissions target and supports the global movement to net-zero emissions as the world strives to meet the Paris Agreement temperature goals. However, carbon pricing will only be effective if it is designed in a way that is tailored to the economic context and complements the broader landscape of policies and regulations.

In the first part of this section we set out the key considerations for Taiwan as it assesses the carbon pricing options. Section 4.2 then proposes viable options given these considerations, including the advantages and limitations of the proposal.

4.1 Key considerations for Taiwan in choosing a carbon pricing instrument

Several barriers could influence the choice of carbon pricing in the short run:

- Coverage of the electricity sector
- Industrial competitiveness, carbon leakage and wider economic impact
- Risks of concentrated market power and insufficient liquidity in an emissions trading system
- Capacity for implementation

These four considerations emerge from a careful analysis of Taiwan's emissions trends, economic structure and energy system, and discussions we had with the EPA, facilitated by a questionnaire regarding local context and capacity.

While the consideration of market power and liquidity is only relevant to implementing an ETS, the other three considerations are relevant to any form of carbon pricing, be it is based on a carbon levy or an ETS. Each consideration poses unique challenges to implementing carbon pricing in Taiwan and should therefore be treated carefully by policymakers.

These considerations suggest that in the short run a carbon levy may be the most feasible option, but in the long run Taiwan could choose to utilise either a levy or an ETS. Constraints on current capacity will, for example, skew the decision towards implementing a carbon levy, but as regulators, policymakers and businesses gain experience with carbon pricing, the option to implement an ETS will open up. Competitiveness concerns may also diminish in the future as governments around the world move to implement more stringent climate policy. Taiwan may also wish to collaborate more closely with other regional markets, which is most easily done via linked ETSs. This can lead to changes both to the underlying CPI being used and to key parameters of design, such as scope, ambition and the use of offsets. Policymakers in Taiwan should keep in mind this potential for change and evolving circumstances when selecting an instrument. Figure 4.1 summarises the key considerations for Taiwan when choosing a CPI and builds on the differences between short run barriers and long-term objectives, as previously discussed in Sections 3.1 and 3.3.

Figure 4.1. Key considerations for carbon pricing in Taiwan

Short-run instrument choice

Implementation capacity
→ Carbon levy preferred
Industry is more familiar with fees but averse to the administrative burden of ETS trading. It takes time to develop rules for market oversight and trading infrastructure.

Secondary market challenges
→ Carbon levy preferred
Taiwan must address the lack of liquidity and concentrated market power if an ETS is used. Options include purchasing and holding limits, frequent auctions, consignment auctions, and expanding ETS scope.

Short-run instrument design

Regulated electricity sector
→ Cover the sector if possible
Taipower can be regulated by a carbon levy after an amendment to the GHG Act. Pass carbon costs to electricity users via a consumption charge on indirect emissions.

Impact on competitiveness
→ Support to mitigate impact
Cost impact will focus on emissions-intensive and trade-exposed industries and can be addressed effectively in both a levy and an ETS. Carbon costs in indirect emissions via electricity use will have limited impact on the wider economy.

Long-run instrument choice and design

Achieving emissions targets
→ **ETS** offers greater certainty in limiting emissions to a fixed level
Long-run cost-effectiveness
→ **ETS** offers temporal flexibility but higher administrative costs

Support low-carbon investment
→ **ETS** offers temporal flexibility but higher administrative costs
Raise government revenue
→ **Levy** may be a more predictable revenue source

Generating co-benefits
→ **Both ETS and a levy** can deliver local co-benefits, e.g. air quality
International cooperation
→ **ETS** linking can improve cost efficiency and build political ties

Source: Authors

4.1.1 Coverage of the electricity sector

An important question in the design of carbon pricing is can it legally cover the electricity sector and specifically Taipower, the vertically integrated public utility? The provisions for an ETS under the GHG Act passed in 2015 exclude public utilities like Taipower. However, the amendment to the Electricity Act in 2017 committed to liberalise the electricity market, breaking up Taipower into a generation company and a transmission and distribution company between 2023 and 2026. In this case, the generation company would no longer be regarded as a public utility and can be covered by an ETS in the future. Furthermore, the amendment to the GHG Act expected in late 2020 may introduce the use of a carbon levy that allows for the regulation of Taipower.

Even if Taiwan can legally cover the electricity sector, the more important questions are *should* this be implemented and if so, *how*? Because decarbonisation would be driven by the ongoing market reform and incentives to deploy renewables, the key issue here is whether or not carbon pricing could complement these policies by providing an effective price signal on emissions from electricity generation.

A carbon price can help to reduce emissions in electricity in three channels: changing the merit order, encouraging low-carbon investment, and reducing demand. A carbon price imposed on electricity generators can be effective for the first two channels, but the final channel depends on whether the carbon price is passed through to electricity consumers in the form of higher retail electricity prices, known as 'cost pass-through'.

The key advantage of imposing the carbon price on electricity generators is that it incentivises supply-side abatement. For instance, a carbon price increases the production costs of coal-fired power plants more so than gas-fired power plants. This may change the merit order if the carbon price is sufficiently high, reducing electricity generated from coal. This further affects the returns on investment and can induce greater investment into gas-fired power plants and renewables. In addition, it is easier to impose the carbon price on electricity generators rather than downstream consumers because generators have greater administrative capacity.

In a fully liberalised electricity market, a carbon price would push up the price of electricity depending on the emissions intensity of the marginal plant. This cost pass-through effectively encourages firms and households to reduce electricity consumption. However, in Taiwan retail electricity prices are heavily regulated by the Government, subject to biannual reviews alongside a limit of no more than 3 per cent change at every review.[23] If retail electricity prices are set such that they do not reflect the carbon price, the incentive to reduce electricity demand is not delivered downstream, and the costs will be incurred mostly by Taipower and other fossil fuel power generators. By contrast, if the carbon price is embedded into the formula that the Government uses to determine electricity prices, the costs can be passed on to consumers and the abatement effect could be as effective as a carbon price under a fully liberalised electricity market.

Supposing Taiwan imposes a carbon price (levy or ETS) on electricity generators, there are different ways to enable cost pass-through to electricity consumers.[24] The available options depend on whether regulations permit the *explicit* pass-through of the carbon price to retail electricity prices, and are summarised as follows:

If regulations permit explicit pass-through:

1. **Embed the carbon price into the formula for determining retail electricity prices:** Under this option the price signal is transmitted throughout the electricity market, encouraging all firms and households to reduce electricity consumption. This option aligns with Taiwan's proposed response to the UN Sustainable Development Goals, which includes the aim of revising the electricity price formula to account for any energy or carbon tax.[25] This is relatively straightforward to implement under a carbon levy due to the expectation that the levy rate remains stable over the short term. As for an ETS, the carbon price would fluctuate over time and such uncertainty would make it harder to determine the appropriate electricity price.

[23] A formula is specified by the Ministry of Economic Affairs for determining the appropriate level of electricity prices, though it has also exercised discretion to deviate from the electricity prices calculated from the formula to directly set prices to ensure affordable electricity.

[24] More guidance on the technical design can be found in the ICAP report for regulated electricity markets.

[25] Based on report published by the Executive Yuan in 2019, under Article 8.11.1.

If regulations prohibit explicit pass-through:

2. **Impose a separate 'consumption charge' on large electricity consumers:** Under this option the retail electricity prices are nominally unaffected by the carbon price but the consumption charge helps to deliver a price signal to large industrial and commercial electricity users for their indirect emissions. Such a measure would be similar to the UK's Climate Change Levy, a downstream tax on business energy use. In the case of a carbon levy, the consumption charge could easily be calculated by multiplying the carbon levy rate with the emissions intensity of electricity. As for an ETS, the consumption charge can be set to fluctuate in line with the market price for emissions allowances.
3. **Impose the carbon price on large electricity consumers for their indirect emissions in addition to the coverage of direct emissions from electricity generators:** In effect this option expands the scope of carbon pricing to cover indirect emissions of large electricity consumers. For a carbon levy, this would be effectively the same as a consumption charge as Option 2. For an ETS, this requires large electricity consumers to surrender allowances for the indirect emissions associated with electricity consumption. The allowance cap will no longer represent total emissions as some emissions are allocated twice: once as a direct emission of electricity generators and again as an indirect emission of large electricity consumers. This is sometimes called 'double coverage' (Acworth et al., 2020). However, double coverage requires a careful design of the cap and requires more administrative capacity downstream.

As these three options illustrate, carbon pricing can be implemented effectively in the electricity sector and co-exist with Taiwan's existing regulations on electricity prices. Therefore, Taiwan should consider introducing a carbon price that covers the electricity sector if possible. The ongoing electricity market reform addresses the non-price barriers facing renewables developers by allowing the creation of new business models and opening access to the power grid. A carbon price that covers the electricity sector could complement this by sending a credible price signal in favour of low-carbon electricity and reduce electricity consumption.

4.1.2 Industrial competitiveness, carbon leakage and wider economic impact

The risk of carbon leakage from carbon pricing is a typical concern for any government considering carbon pricing. Carbon pricing makes emitters internalise the cost of their emissions, but higher production costs could make firms less competitive internationally, reducing exports and making imports more likely. Carbon leakage occurs if carbon pricing makes production costlier to a sufficient extent that firms decide to either relocate to other countries without a carbon price or lose market share to foreign producers. As a result, emissions are merely displaced rather than truly abated.

This concern is often targeted at emissions-intensive and trade-exposed (EITE) industries because they will be disproportionately affected by a carbon price. Emissions intensity matters as it directly determines the cost impact borne by companies. Trade intensity matters because firms that are highly exposed to foreign competition may lose customers if they pass through carbon costs in the form of higher prices.

Regulators typically spend a lot of time identifying EITE industries in their jurisdictions in order to assess the risk of carbon leakage and develop policy measures to mitigate the risk. EITE industries typically include refineries, basic metals (e.g. iron, steel, aluminium), cement, and chemicals. However, these may vary across jurisdictions, especially the export orientation of industries.

Despite the concern, empirical studies to date find little evidence of carbon leakage (Venmans et al., 2020). There is no consensus within the literature as to why this is the case. One possible reason is that many jurisdictions that have adopted carbon pricing have also implemented a range of industry support measures, such as those outlined in Section 3.2.

Regardless of the means to support affected industries, policymakers need to carefully balance the need to strengthen incentives for emissions reductions and industry interests. There is a real risk that excessive free allowances (under an ETS) or exemptions (under a levy) could render the carbon pricing policy ineffective because of weak financial incentives. One obvious way to mitigate this risk is to limit the extent of free allowances and exemptions. For an ETS, one option would be to use consignment auctions to support industry while preserving financial incentives. A consignment auction is a mechanism through which regulated entities receiving free allowances are required to offer their allowances for auctioning, but in exchange receive the revenues of auction sales. In this way, policymakers can still auction off a reasonable proportion of emissions allowances to strengthen the price signal, while shielding industry from significant revenue impact (Burtraw and McCormack, 2016, 2017).

The development of border carbon adjustments (BCAs) in jurisdictions such as the European Union could also affect EITE industries in Taiwan. In the EU ETS, the free allocation of emissions allowances may have provided an adequate leakage protection while carbon prices were low, but faces challenges in the longer run, as the EU's net-zero target leads to higher carbon prices, and reduces the capacity to provide free allocation in the future. Since Ursula von der Leyen became president of the European Commission, BCAs have rapidly become a political focus. The Commission is currently developing a proposal for the implementation of BCAs as an alternative way to address carbon leakage and increase climate ambition in countries with less stringent carbon pricing policy. While the implementation of an EU BCA is likely a number of years away, if Taiwan has still not implemented an effective carbon pricing instrument, EITE industries such as steel and chemicals could become susceptible to such measures in the EU and other jurisdictions.

In Taiwan, the electronics sector is one of the most trade-exposed industries, employs the most workers and serves as an important pillar for economic growth. The electronics sector does not produce significant direct emissions but does have major *indirect* emissions via its electricity consumption. Therefore, stakeholders may be concerned that the sector would suffer under a carbon price that applies to indirect emissions. However, as electricity only accounts for about 2 per cent of production costs in the electronics sector, the impact of carbon costs should be limited relative to the typical EITE industries.[26]

The risk of carbon leakage depends on the relative strengths of carbon pricing across a jurisdiction. The largest regional competitors against Taiwanese exporters are located in South Korea, Japan and China. For instance, Taiwan was the world's third largest exporter of electronics in 2018, with a market share of 7 per cent, lagging behind only China (27 per cent) and South Korea (8 per cent), while leading Japan (4.6 per cent), Malaysia (4.2 per cent) and Vietnam (4.1 per cent).[27] In the typical EITE industries such as chemicals and steel, the regional picture is similar, with Taiwan behind only China, South Korea and Japan in terms of export market share in the region.[28] Importantly, all three of those countries are implementing a carbon price. The carbon price in the South Korean ETS has remained well above US$20/t$CO_2$ for most of the last three years, China's carbon prices have ranged between US$1 and 12/t$CO_2$ depending on the region, while Japan has a carbon tax of approximately US$3/t$CO_2$ (World Bank, 2020). This should reduce the risk of carbon leakage from Taiwan. However, because many countries in South East Asia have not yet implemented carbon pricing, there could still be grounds for concern over potential carbon leakage. If this does become an important issue, Taiwan can still follow some of the measures outlined above to mitigate the impact on industrial competitiveness.

A more detailed analysis at the product level is required to understand which sub-sectors in Taiwan would incur disproportionately large impacts on competitiveness. As described in Section 2.3.3, the CIER think tank is currently conducting a detailed assessment of the potential

26 Based on 2016 Use Table at Purchasers' Prices, published by National Statistics.

27 Based on 2018 global trade data. HS code 8.

28 Based on 2018 global trade data. HS code 37, 72, 73.

impact of carbon pricing on various industries in Taiwan. A preliminary classification suggests that EITE industries represent at least 38 per cent of the gross value-add from the manufacturing sector and employ at least 970,000 people.[29] Therefore, the risk of carbon leakage should be treated carefully in Taiwan.

In terms of household distributional affects, the impact of carbon pricing will be felt mainly through higher electricity prices, if electricity emissions are covered. However, concerns over higher electricity prices in Taiwan could be overstated. Based on the average emissions intensity in the generation mix, a carbon price of NT$300/t$CO_2$ (US$10/t$CO_2$) would only amount to a cost equivalent to 6 per cent of existing electricity prices. Given that the cost of electricity represents only 2 per cent of production costs on average outside the EITE sectors, the impact of a carbon price through higher electricity prices should amount to approximately a 0.1 per cent increase in costs, even with full cost pass-through of the carbon price to electricity prices.[30]

4.1.3 Risks of concentrated market power and insufficient liquidity in an ETS

If Taiwan implements an ETS, the relatively small size of its market could lead to challenges regarding the concentration of market power and liquidity. Concentration of market power can distort auctions and secondary market trading, while insufficient liquidity could hamper price discovery and smooth functioning of the secondary market. Both challenges depend on the number and type of regulated entities covered by an ETS and therefore significantly affect the appropriate scope of coverage.

Concentrated market power arises when the ETS is dominated by a few big buyers or sellers of emissions allowances. This is a significant concern because the top 30 industrial emitters contribute up to 80 per cent of carbon emissions from the industrial sectors. In particular, if the electricity sector is included under a Taiwan ETS and Taipower participates as a single electricity generation company, it will have an outsized market power: it generated 77 per cent of Taiwan's electricity in 2016, resulting in about half of Taiwan's total carbon emissions. In the absence of suitable countermeasures, entities can abuse their market power by deliberately hoarding emissions allowances, which pushes up their price. Excess market power can reduce the quantity of trading, which in turn leads to an increase in abatement costs. One option to mitigate this – which may be permissible under the existing GHG Act – is to allocate the electricity to multiple end users (such as large electricity users) who can then trade in the market. This may help to reduce risks from concentrated market power. However, such an approach would only reduce demand for electricity, and would not incentivise moving to cleaner sources of supply.

There are measures to prevent market participants from gaining too much market power but given the relative share of Taipower's overall emissions, the degree to which these would be effective is not clear. One option is to hold frequent auctions of emissions allowances, which help to provide transparency and reduce price volatility. Frequent auctions mean that the value for sale at each individual auction is reduced, decreasing the risk of manipulation of the auction itself and making it more difficult for any one participant to gain too much market power in the secondary market. For example, the Regional Greenhouse Gas Initiative (RGGI) in the United States and the California-Québec cap-and-trade agreement both have joint quarterly auctions. The large-scale EU ETS auctions are held several times a week at different trading platforms. Another option is to impose auction purchase limits and holding limits, such as in California's ETS (PMR, 2016). This can directly prevent the hoarding of emissions allowances by large entities. The use of consignment auctions as described above would also prevent excessive market power from individual entities. However, it still will be challenging to apply these designs in Taiwan if Taipower participates in the ETS as a single entity.

[29] Based on 'high risk' sectors identified from the preliminary carbon leakage risk assessment by the CIER think tank, which adapts the classification matrix of emissions intensity and trade intensity developed by the California Air Resources Board.

[30] Based on 2016 Use Table at Purchasers' Prices, published by National Statistics.

Even if the issue of market power is addressed, there is a risk of insufficient secondary market liquidity in Taiwan due to the small number of participants. For Taiwan, carbon pricing is likely to focus, at least initially, on the 290 large emitters that currently report their greenhouse gas emissions to the Government. This is on a par with the number of entities with mandatory reporting in the New Zealand ETS (221), although the latter also has over 2,000 entities participating on a voluntary basis (ICAP, 2019).

To improve market liquidity, an ETS could be designed with borrowing, consignment auctions and government 'market-making'. Policymakers could allow borrowing of emissions allowances across compliance periods. Under this arrangement, entities can use allowances that they will receive in future compliance periods within the current compliance period. In other words, entities can emit more today while promising to surrender an equal or greater number of allowances later. This measure not only increases the supply of allowances to provide market liquidity, but also brings additional benefits such as providing temporal flexibility to firms and reducing short-term price volatility. However, there are limitations to this measure, including the difficulty of assessing the creditworthiness of entities, adverse selection of borrowers, greater political pressure to delay climate action, and uncertainty in reaching emissions targets (PMR, 2016).

Consignment auctions, mentioned earlier, would also improve market liquidity because this measure supports price discovery in auctions and forces the redistribution of some freely allocated allowances (Burtraw and McCormack, 2016).

Finally, the Government could also directly provide liquidity for the secondary market as a 'market-maker', in a role akin to that of a central bank in financial markets, injecting liquidity whenever necessary. Korea offers an example of this: the Korea Development Bank and the Industrial Bank of Korea were officially designated as market-makers in the Korea ETS (ICAP, 2020). The two banks draw on a government reserve of five million emissions allowances and trade in the market to provide liquidity.

Linking a Taiwan ETS with other jurisdictions where an ETS is being considered, such as Indonesia, Vietnam, Thailand or the Philippines, or with jurisdictions where an ETS is already established, such as South Korea, could also improve market liquidity. However, this is likely to be a politically challenging move given that most countries do not formally recognise Taiwan. Linkage would allow regulated entities in Taiwan to use emissions allowances issued in other ETSs for compliance purposes, in effect expanding the supply of emissions allowances on the secondary market. However, linking up with another ETS would require long periods of negotiation so that the many technical features of the ETSs would align. Creating such a link would be difficult for Taiwan because of the limited number of ETS initiatives with which cooperation is feasible in the region.[31]

4.1.4 Capacity for implementation

Taiwan has most of the capacity required for implementing a carbon levy soon. The EPA has substantial experience in enforcing fees similar to a carbon levy, such as fees for water and air pollution. In turn, businesses are familiar with the regulatory arrangement through their experience with those fees. Importantly, there are also accredited service providers to audit and verify reported emissions.

While these are broadly sufficient for implementing a carbon levy and although work has been undertaken to establish the design of the ETS (including domestic offset systems and a pilot trading platform as well as an MRV system for major emitters in the energy and industrial sectors), further capacity-building is required to implement an ETS as it requires substantial additional capacity in market oversight, trade infrastructure and allocating free emissions allowances. A detailed survey of Taiwan's existing implementation capacity is summarised in Table 4.1.

31 This is complicated by Taiwan's relationship with China, leaving the Korea ETS as the remaining option for Taiwan to link to.

Table 4.1. Carbon pricing implementation capacity in Taiwan

Carbon pricing instrument	Implementation	Regulatory capacity	Business capacity
Carbon levy; Emissions trading system	**Compliance**	The EPA has credibility in enforcing various existing environmental fees.	Firms have access to emissions verification services but limited legal advisory services.
Carbon levy; Crediting*; Emissions trading system	**Monitoring, reporting and verification (MRV)**	Established MRV mechanism for greenhouse gas emissions in place since 2016.	Larger emitters are already mandated to report emissions.
Crediting*; Emissions trading system	**Market oversight**	The EPA has not yet consulted the financial authority on emissions trading arrangements.	Businesses are generally willing to comply with regulations but none are familiar with emissions trading.
Crediting*; Emissions trading system	**Trade infrastructure**	A registry is in place for auctioning renewable energy certificates. The EPA has developed a pilot carbon trading platform but it is not fully tested.	There is currently no market exchange for environment-related financial products. Some brokers are experienced in commodities but they are limited in scale.
Emissions trading system	**Allocation of free emissions allowances**	There is data on historical emissions from the largest emitters but not on the production scale required for calculating the free allowances.	Industry is not familiar with the concept of an ETS, nor with allocation of free allowances or the implications for competitiveness.

*Notes: Green indicates high existing capacity for implementation, amber moderate capacity and red little to no capacity. *See Appendix 2 for a more detailed discussion on the use of offsets within emissions trading systems. Source: Authors based on inputs from the Taiwan EPA.*

Business capacity to comply with carbon pricing is generally stronger upstream (see Appendix 2), though large electricity users are also well equipped to report their emissions. Businesses that directly emit more than 25,000 tCO_2e a year have been reporting their greenhouse gas emissions to the Government under a mandatory arrangement since 2016.[32] Large electricity users have not been required to report their indirect emissions but it should be relatively simple for them to do so if Taiwan decides to cover those emissions with carbon pricing. In the transport sector, the capacity for fuel suppliers to comply with carbon pricing is also relatively high as there is good data on fuel sales and emissions intensities.

To implement an ETS, the Government would need to develop market regulation and trading infrastructure for the secondary market. A first step in this direction would be to establish a registry of emissions allowances, which are used to hold and transfer allowances and thus facilitate trade. A registry needs to be built on robust IT infrastructure and preferably would be designed to support future exchange-based trading, as well as enabling individual companies to manage their accounts via brokerage services. For an ETS to be established, an auction platform and related governance mechanisms are also likely to be needed. In the design of an ETS, the Government is likely to need additional regulations on emissions allowances and decide the rules governing trade. This will require close coordination between the EPA, the financial authority and other agencies, which could take several years.

[32] Apart from entities that emit over 25,000tCO_2 a year, mandatory reporting requirements also cover all electricity generators, refineries, and manufacturers of iron and steel, cement, semiconductors, and TFT-LCD.

4.2 A roadmap for carbon pricing

Below we propose a roadmap to implement carbon pricing in Taiwan. Given Taiwan's context and key considerations, we recommend that the implementation of carbon pricing begin with a carbon levy. The following sections describe the reasoning and design for such a carbon levy in the near term (Section 4.2.1), the advantages and limitations of this proposal (Section 4.2.2), and options in long-run policy development (Section 4.2.3).

4.2.1 A levy to introduce carbon pricing to Taiwan

Our analysis leads us to recommend that Taiwan should first look to implement a carbon levy, which can be implemented relatively quickly and easily.

The reasons for implementing a carbon levy as opposed to an ETS are threefold. First, businesses are more prepared for and slightly more amenable to a carbon levy because they are familiar with fees associated with environmental protection. Second, the Government has most of the necessary infrastructure and capacity to implement the levy but not an ETS. Third, with appropriate institutional safeguards a carbon levy provides greater price predictability for both businesses and government in forward-planning. If Taiwan were to implement a carbon levy in the near future, the task for policymakers would then be to decide the appropriate scope and level of ambition.

We recommend the carbon levy covers large emitters in manufacturing and, if possible, electricity generation.

The focus on large emitters complements the pre-existing reporting of emissions for large emitters. The electricity sector is a large source of emissions in Taiwan and its inclusion would cover the indirect emissions of households and the services sector. If the electricity sector were to be covered by carbon pricing, we recommend either embedding the carbon price into the retail electricity price formula or imposing a separate but proportional consumption charge on large electricity consumers. However, as we acknowledged above, it could be challenging to cover the electricity sector due to the substantial regulatory coordination required for the electricity sector (see Section 4.1.1). Regardless of whether the electricity sector is covered by carbon pricing or not, complementary policies to support the ongoing market reform and a transition to renewables would still be required.

In the case of the transport sector, Taiwan may wish to continue using its Fuel Fee or complement it with the carbon levy.[33] Incorporating transport into the carbon levy is justified if the Fuel Fee serves to correct for externalities other than greenhouse gas emissions, such as air pollution, congestion, and the use of the road network. In this case, the carbon levy does not replace the need for a Fuel Fee. The recommendation balances the objective of Taiwan to incentivise cost-effective mitigation with the need for relatively easy implementation in the near term.

We recommend that the levy is started at a low level (around US\$10/tCO_2e) with a clear trajectory to increase the levy to levels required to meet international climate goals under the Paris Agreement.

Starting with a relatively low price will enable firms to familiarise themselves with the system while still having the full policy in place. The low starting levy will provide time to further consider other design requirements. For example, under a higher carbon price there may be the need for partial exemptions or other policy options to reduce competitiveness impacts and leakage risk. A low initial levy also minimises the initial impact on competitiveness and the need for additional industrial support. In the long run, a clear price trajectory will need to be established and maintained. For example, the Government could indicate a strong commitment to escalate the carbon price over time, such as by increasing the levy rate by 10

[33] The Fuel Fee (汽燃費) is charged per vehicle on an annual basis. Unless it is reformed to charge users based on fuel consumption, it is not a good substitute for a carbon price on emissions from the transport sector.

per cent each year. This is necessary to provide a credible price signal to support investments in low-carbon technology.

In comparison, an international expert commission led by Joseph Stiglitz and Nicholas Stern recommended a global carbon price of US$40–80/t$CO_2$ by 2020 and US$50–100/t$CO_2$ by 2030 (Carbon Pricing Leadership Coalition, 2017). Recently published research by Kaufmann et al. (2020) derived similar values. To achieve net-zero by 2050 they suggest a carbon price of US$52/t$CO_2$ in 2025 and roughly US$100/t$CO_2$ in 2030. This is also consistent with the findings from Burke et al. (2019), who suggest a carbon price that is consistent with net-zero would start at US$65/t$CO_2$ (with a range of US$52–130) in 2020, reaching US$98/t$CO_2$ (US$78–182) in 2030.

Starting with a carbon levy does not exclude the option to transition to an ETS once the required capacity is developed and industry is more familiar with the system.

Certain aspects of the levy can be designed in a manner that can facilitate a transition to an ETS. For example, the carbon levy could be designed as a fixed price ETS;[34] this would support the development of infrastructure that can be used to transition to an ETS, such as an emissions allowance registry, if desired in future. Moving towards an ETS would require extra capacity within the EPA and government departments with skills relevant for the operation of the secondary market. Many of the competencies that need to be developed overlap with those required for regulation of the financial sector.

Implementation of a carbon levy requires a change in legislation, more detailed analysis and stakeholder engagement.

An amendment to the GHG Act is required to allow for the use of a carbon levy as a complement to an ETS. Taiwan should conduct a more in-depth analysis on the suitable range for the levy rate and on detailed design choices, particularly if transition to an ETS is preferred. Starting stakeholder engagement early to prepare regulated entities for the implementation of a levy will be hugely effective. Workshops with industry representatives can explore the exact procedure to implement a levy and the administrative processes that could entail. Through engagement, policymakers should also gauge the acceptable trajectory for the carbon price and explore specific ways to support industries that will be negatively affected by the levy.

4.2.2 Advantages and limitations of this proposal

- ***Advantage:* A carbon levy will be relatively quick to implement and can start delivering cost-effective mitigation.** In line with economic theory, the proposal of a carbon levy is likely to be more cost-effective than command-and-control policy instruments. The administrative costs for businesses are also lower than in an ETS, given businesses' familiarity with similar systems for paying fees for water and air pollution. Following the recommended carbon levy allows the EPA to implement a carbon price that has low requirements on implementation capacity, with the 290 large emitters already reporting their emissions to the online emissions registry. Therefore, the carbon levy best meets the desire to incentivise cost-effective mitigation while being easy to implement in the near term. This allows Taiwan to move more quickly on meeting its emissions targets.
- ***Limitation:* A carbon levy cannot provide Taiwan with certainty in reaching its emissions targets.** As the levy does not place a cap on emissions, in theory firms can maintain their current emissions level. However, provided the Government escalates the levy's ambition over time and adapts to the market response, the levy should deliver significant incentives for abatement. Further study of marginal abatement costs could help estimate the expected emissions reductions but there will still be some uncertainty.
- ***Advantage:* Through setting a carbon levy, the Government benefits from a predictable revenue stream while business benefits from price stability.** While a levy is uncertain in its emissions reduction, since the levy rate is set by the Government it provides more certainty

[34] By using the same infrastructure as an ETS, e.g. emissions allowances registry and online exchange platform, but fixing the price of allowances.

over the level of revenue raised. Since the levy is a fixed price that is adjusted periodically, the price signal is stable, provided that adjustments are well justified and clearly communicated. This benefits businesses that are better able to plan abatement investments.

- ***Limitation:*** **Taiwan's ability to coordinate with regional and international carbon pricing policy is limited under a carbon levy.** Carbon pricing cooperation between jurisdictions has generally been between different ETSs. However, high levels of coordination between systems is rarely achieved at an international level. It is likely that if Taiwan transitioned to an ETS it would be technically and politically challenging for Taiwan to link with other systems. Any ETS link will likely be a longer-term objective, even if it is politically possible. With regards to a potential EU carbon border adjustment measure, coordination over carbon price levels, emissions benchmarking, sectoral coverage and leakage mitigation measures should be considered in order to avoid or limit the impact of such a policy.

4.2.3 Long-run options for carbon pricing development

Fundamental policy objectives rather than implementation capacity should determine the long-run development of a carbon pricing policy in Taiwan. The proposal we have set out is heavily influenced by the ease of initial policy implementation upon the passing of the necessary legislation. In the long run, the capacity for implementation will no longer be a binding constraint for policymakers and therefore should not be the determining factor for policy design. The Government should gradually move carbon pricing policy towards a configuration that aligns with the policy priorities described in Section 3.3. The optimal design for carbon pricing in Taiwan will depend on the importance of pursuing goals such as achieving emissions targets, raising stable revenue for the Government, and mobilising investment in low-carbon technologies.

Therefore, policymakers must develop a consensus on the long-term role of carbon pricing and its implications for instrument selection. Long-term objectives may be better served by a different carbon tax levy, or by moving to an ETS. For instance, an ETS could provide greater certainty of achieving Taiwan's long-term emissions target. This report shows how long-term policy objectives should shape this choice, but does not propose any single approach for Taiwan.

5. Conclusions and summary recommendations

In this report we have set out the key elements of Taiwan's environmental, economic and policy context that are relevant for the introduction of carbon pricing.

We have identified the following core issues to be considered in the lead-up to policy implementation:

- **The benefits and costs of regulating the electricity sector, Taiwan's major source of emissions.** Consideration here must be given specifically to the different options for regulating Taipower, the vertically integrated public utility.
- **The potential impacts of carbon pricing on Taiwan's competitiveness**. For this small, open economy, detailed consideration must be given to the potential risk of carbon leakage and policy options to reduce these risks.
- **The functioning of the secondary market if Taiwan implements an ETS.** The relatively small size of its market and the concentration of emissions in a small number of players could lead to challenges regarding the concentration of market power and liquidity in secondary markets.
- **Taiwan's existing capacity to implement different types of carbon pricing instruments.** Taiwan has most of the capacity required for implementing a carbon levy soon, but further capacity-building is required to implement an ETS.

On the basis of these considerations we recommend that Taiwan:

- **Start with a simple carbon levy, set at an initially low level, but with a clear trajectory to reach higher prices.** By starting with a low price Taiwan can learn by doing, to understand the operation of the levy and its impacts on covered firms. However, a clear trajectory of price increases over time is needed to ensure sufficient decarbonisation incentives.
- **Retain the option to alter the design of its carbon pricing over time, as circumstances change.** The simple approach we recommend can be designed with inbuilt flexibility, enabling the policy to be improved over time and providing the opportunity to move to an emissions trading system (ETS) if desired at a future date.
- **Cover the full set of greenhouse gases from large emitters in manufacturing and, if possible, electricity generation.** The focus on large emitters complements the pre-existing reporting of emissions for large emitters. The electricity sector is a large source of emissions in Taiwan and its inclusion would cover the indirect emissions of households and the services sector.

This study presents the first steps and broad parameters for the introduction of a carbon price but further action is required to move towards implementation. This includes clarification of the policy design details and the development of enabling legislation. Thorough stakeholder consultation and capacity-building will be essential to ensure that the policies adopted are fit for purpose.

We have presented a flexible approach for Taiwan's short-run carbon pricing implementation; in the long run the development of Taiwan's carbon pricing policy should evolve in line with its underlying policy objectives. Carbon pricing is a powerful policy tool and as such jurisdictions often trade-off several objectives when deciding on the type of carbon price to adopt. For Taiwan, the key question will be whether to retain a carbon levy or to move to an ETS as its context, capabilities and objectives change. This choice should be informed by a structured assessment of the role that carbon pricing plays in Taiwan's broader environmental, economic, fiscal and foreign policy.

As Taiwan's emissions continue to rise, the cost of climate action will increase. However, as the world moves to enhance climate action in a manner that is ambitious and consistent with the Paris Agreement, Taiwan is well placed to build on its strengths to develop a competitive low-carbon economy. The time appears right for Taiwan to introduce carbon pricing, with its substantial benefits, as a core plank of its climate policy mix.

Appendix 1: Sources of carbon dioxide emissions in Taiwan

Source of carbon dioxide emissions	**2017 CO_2 emissions**	**2010–2017 CAGR***	**2014–2017 CAGR**
Energy sector	269.5	1.1%	1.4%
Energy industry	187.1	1.9%	2.2%
Electricity and heat generation	168.6	1.7%	2.6%
Electricity	126.8	2.5%	5.0%
Combined heat and power (CHP)	41.8	-0.3%	-3.5%
Heat	0.0		
Petroleum refineries	8.3	4.1%	-1.4%
Production of solid fuels and others	10.2	3.5%	-1.2%
Production of solid fuels	10.2	3.5%	-1.2%
Other energy sector	0.0		
Manufacturing industry and construction	36.7	-1.7%	-1.9%
Ferrous metals	8.5	-1.6%	-1.0%
Non-ferrous metals	0.2	-4.2%	-9.4%
Chemicals	12.1	-1.9%	0.5%
Paper and pulp	1.9	-1.6%	-6.6%
Food, beverages and tobacco	0.9	-1.6%	-2.3%
Non-metallic mineral products	5.9	-2.8%	-5.5%
Others	7.1	-0.3%	-2.1%
Transport	36.2	0.6%	1.5%
Aviation	0.3	3.5%	3.3%
Domestic aviation	0.3	3.5%	3.3%
Road	35.3	0.8%	1.4%
Rail	0.1	-6.0%	-11.7%
Shipping	0.6	-6.2%	6.3%
Domestic shipping	0.6	-6.2%	6.3%
Others	0.0		
Other sectors	9.4	-1.1%	-1.0%
Service Industry	3.8	-1.5%	-1.3%
Residential	4.4	-1.4%	-0.1%
Agriculture, forestry, fishery and husbandry	1.2	1.1%	-3.6%
Industrial processes and product use sector	15.2	-2.4%	-4.9%
Mining industry (non-metal process)	6.3	-4.5%	-10.5%
Chemical industry	1.7	1.0%	-3.2%
Metal process	7.2	-1.1%	0.9%
Others	0.0	0.0%	1.7%
Agriculture sector	0.0	-7.6%	-8.1%
Land use and forestry sector	-21.5	0.0%	0.1%
Waste sector	0.1	-7.6%	-6.3%
Total	**284.8**	**0.8%**	**1.0%**

*Notes: *CAGR = compound annual growth rate. Colours denote high or low values.*

Source: 2018 National Communications of the Republic of China (Taiwan) under the UNFCCC

Appendix 2: Carbon pricing design considerations

The design of carbon pricing across jurisdictions reflects the different policy objectives and capacity constraints. The choice of carbon pricing instrument (i.e. between a carbon tax or an emissions trading system) affects several interrelated policy decisions that are highly consequential to the effectiveness of carbon pricing:

- Scope of covered sectors and gases
- Cap and tax level
- Use of offsets
- Supply adjustment mechanisms for an ETS

These policy areas are key to considering which carbon pricing instrument (CPI) may be most appropriate to Taiwan's specific circumstances. They do not, however, cover the whole array of detailed design considerations that would be required for implementing either instrument.

The limitations of a CPI can be mitigated through appropriate designs. For an ETS, its price volatility could be reduced via the use of supply adjustment mechanisms (SAMs), and the difficulty of covering some sectors could be addressed via the use of offsets. For a carbon tax, the uncertainty around achieving specific emissions targets could be mitigated by setting a more ambitious tax level. This Appendix introduces the relevant lessons learned from the international experience on such policy design issues.

Scope of covered sectors and gases

The scope of a CPI refers to the choice of emissions sources to be liable. Scope is generally varied by adjusting the economic sectors or types of emissions covered, and through restrictions on the size of facilities that may be liable. More limited coverage generally requires lower levels of institutional capacity and lower administrative costs but this can vary substantially across sectors and sources.

Generally, for an ETS to function well it must have sufficiently broad coverage to include a wide pool of sophisticated firms that can efficiently participate in trading in the secondary market. This is important both to ensure sufficient trade for the market to function and to reduce the risk that market players with large amounts of market power will corner the market. The coverage required to meet this need will differ depending on different jurisdictions' levels and composition of emissions. In most cases, an ETS will cover emissions from the electricity sector, which is a source of high capacity of covered entities for trading, and also benefits from the ease of identifying sources of emissions and the prevalence of existing reporting requirements for other environmental purposes. Most ETSs therefore cover the power and industry sectors, although newer initiatives are beginning to cover additional sectors. This includes emissions from buildings (e.g. Tokyo-Saitama), transport (e.g. California-Québec), and waste (e.g. South Korea, New Zealand, Australia). Currently, only New Zealand covers the forestry sector and no system yet covers agriculture. Greenhouse gas coverage depends on jurisdictions' emissions profile and covered sectors. For example, any jurisdiction covering waste would necessarily be required to cover methane (CH_4) emissions.

A carbon tax can operate effectively with more limited coverage and a smaller pool of covered firms. As a carbon tax does not require trading of emissions allowances, it does not face equivalent risks of market misconduct or the need for liquid secondary market trade. This means that taxes are often used to cover more concentrated sources of emissions. For instance, carbon taxes often cover transport fuels by covering only a small number of firms, while often allowing them to draw on the taxation and reporting infrastructure that is used for fuel excise taxes in many jurisdictions. Table A2.1 presents a summary of the sectoral and greenhouse gas coverage of major existing ETSs and carbon taxes.

The choice of scope also requires determining the point of regulation and thresholds for inclusion, affecting which firms have compliance liabilities, and the number of entities covered by the CPI. Emissions can be regulated at different points in the supply chain. Liabilities are incurred either at the 'point source', where emissions are physically released into the atmosphere; before the point source (upstream); or after the point source (downstream). Both an ETS and carbon taxes can be applied at various point in a supply chain but should be designed to ensure well targeted incentives in priority sectors. For instance, California uses a hybrid approach, with facility level liabilities for some emissions sources such as power generation and industry, and upstream coverage for some sources like transport where applying liabilities at the point of emissions would impose excessive administrative costs. It is relatively convenient to apply a carbon tax at the point of fuel sale (upstream from emissions) if there are existing fuel taxes. For example, Mexico's carbon tax covers all fossil fuels except natural gas, and Alberta's[35] covers diesel, petrol, natural and propane gas in all sectors.

Many CPIs restrict coverage to those over a certain emissions threshold, to make monitoring more straightforward. The use of thresholds can help ensure that lower capacity firms do not face carbon pricing liabilities while enabling most emissions from a source or sector to be covered. In Mexico, only entities that generate over 100,000 tonnes of CO_2 annually are liable under the ETS. South Korea uses a dual mechanism to determine the threshold, covering emissions for specific facilities that emit over 25,000 tonnes of CO_2 annually in companies that emit more than 125,000 tonnes of CO_2 annually. Other jurisdictions have used other proxies to enable coverage; for instance, Chile implemented a carbon tax with liable entities classified by the size of the boiler or generator they use (World Bank, 2017).

[35] Alberta's new government repealed the carbon tax in May 2019.

Table A2.1. Sectors and greenhouse gas coverage under example carbon pricing instruments from around the world

	Sector(s) or fuel(s)	Greenhouse gas(es)
Emissions trading systems		
Australia (former) Carbon Pricing Mechanism	Power, industry, waste, and fugitives	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6
California-Québec (Western Climate Initiative)	Power, industry, transport	CO_2, CH_4, N_2O
Chinese national ETS	Power	CO_2
European Union ETS	Power, industry, intra-EU aviation	CO_2, N_2O, PFCs
New Zealand ETS	Stationary energy, industrial processes, transport, waste, forestry	CO_2, CH_4, N_2O, SF_6, HFCs and PFCs
Regional Greenhouse Gas Initiative (RGGI) (Northeastern US)	Power	CO_2
South Korea ETS	Power, industry, buildings, transport, waste	CO_2, CH_4, N_2O, PFCs, HFCs, SF_6 (+indirect electricity emissions)
Tokyo-Saitama ETS	Buildings	CO_2
Carbon taxes		
Alberta (former) carbon tax	Diesel, petrol, natural gas, propane	CO_2
British Columbia tax	Fossil fuels in heat and electricity	CO_2*
Mexico carbon tax	All fossil fuels except natural gas	CO_2
Singapore carbon tax	Industrial facilities, fuel combustion and industrial processes and product use (IPPU)	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6, NF_3
France carbon tax	All fossil fuels used in installations not covered by the EU ETS	CO_2
Sweden carbon tax	All fossil fuels used in transport and heating	CO_2
South Africa carbon tax	Fossil fuel combustion, industrial process emissions and fugitive emissions	CO_2, CH_4, N_2O, HFCs, PFCs, SF_6
Ukraine carbon tax	All fossil fuels used in stationary sources	CO_2

Notes: British Columbia notes its tax rate per CO_2e but no information on additional gases was available.
Source: Authors

Ambition (cap and tax level)

The stringency or ambition of the regulation will determine the level of abatement achieved from the policy. A tighter ETS cap will result in higher prices, therefore incentivising more abatement. The same applies for a higher tax level under a carbon tax. Policymakers may find a high ambition (tight cap/high tax) more feasible with some CPIs than others. Political agreement to rapid reductions in an ETS cap may be more politically acceptable than rapid rises in the price of a carbon tax. How different levels of ambition for the carbon tax/cap will impact key areas of concern can be modelled to provide analytical evidence for the level of cap or tax.

Depending on the approach taken, ETS caps may need to be reviewed regularly. Given experience to date we can identify at least three approaches for approaching the relationship between covered and uncovered sectors in the development of caps:

- Effort-sharing between covered and uncovered sectors, as adopted by the EU ETS
- Emissions trading as a safeguard to ensure targets are achieved, as in the early years of the Californian system
- Emissions trading as the primary driver of economy-wide mitigation, as in New Zealand and in Australia's prior carbon pricing mechanism

Setting an appropriate carbon tax level is a bigger challenge, with many carbon taxes around the world inadequate to trigger substantial emissions reductions. Where an ETS provides at least a predictable trajectory for emissions over time, if a carbon tax results in emissions that are below or above a jurisdiction's target it can be very difficult to know if this is a temporary aberration or a signal of a longer-term trend. Current carbon tax levels span from around US$1/t$CO_2$ in Ukraine to over US$100/t$CO_2$ in Sweden, with most emissions priced below US$30/t$CO_2$ (World Bank, 2019). For instance, the current carbon tax in Singapore is set at about US$3.60/t$CO_2$e (SG$5/tCO_2e). Carbon taxes are most impactful if set at a high level and sustained over time (Haites, 2018). In contrast, most carbon taxes to date are too low to achieve the targets of the Paris Agreement (CPLC, 2017).

Use of offsets

A carbon tax or ETS can be linked to crediting mechanisms by allowing credits to be used for compliance, generating a demand and price for those credits. Under a crediting mechanism, verified emissions reductions or removals such as afforestation will create a supply of credits. Regulated entities under a CPI can then purchase these credits for compliance. For instance, in Phase 3 of the EU ETS, credits from programmes like the Clean Development Mechanism (CDM) and Joint Implementation could be used for compliance, whereby regulated entities purchase those credits to 'offset' some of their emissions (European Commission, 2020). In Colombia, domestically sourced credits from a variety of recognised carbon standards, including CDM, VCS and Gold Standard, can be used by regulated entities to fulfil Colombia's carbon tax obligations (OECD, 2019).

Offsets credits can be sourced from domestic or international crediting systems. Using an international system may be more straightforward and carry a lower administrative burden. However, policymakers will lose some control over the quality of these credits. A domestic system affords the policymaker greater control over the quality and nature of the offsets but requires a greater level of capacity. Subnational jurisdictions have the option of using national offset schemes. For example, California has an offset protocol that allows for offsets from US agriculture and forestry, in addition to methane capture and ozone-depleting projects.

The benefit of linking a carbon price with crediting mechanisms is to incentivise mitigation in sectors, activities or regions where there are barriers to direct coverage under a CPI. For example, the agricultural sector has traditionally been difficult to cover because individual emitters (i.e. farms) are often too small and numerous to be effectively regulated. The demand for credits provides a positive incentive for entities in uncovered sectors to abate emissions, allowing them to 'opt in' to a carbon price incentive if cost-effective abatement is possible. Allowing credits from other jurisdictions or sectors not covered by the CPI also expands the amount of abatement options in the market, reducing the overall cost of mitigation and compliance. Allowing verified credits for compliance under regulatory systems is also a useful way for policymakers to understand if it would be feasible to bring uncovered sectors under the ETS and tax scope in the future.

Domestic offsets can build readiness for participating in carbon pricing mechanisms by building firm capacity and creating 'business ecosystems' that support trade. By encouraging the establishment of mechanisms for measuring emissions reductions and market trading, crediting builds capacity for the entities conducting the projects in uncovered sectors. For instance, it can also improve the knowledge and capacity of financial institutions funding projects in these sectors and of the verifiers measuring emissions.

Offset crediting mechanisms can provide a form of cost containment when linked with carbon pricing mechanisms. If firms are struggling to meet their obligations under an ETS, offset credits may be used to fulfil these requirements. For instance, domestic offset credits can be used for a limited amount of compliance in the California ETS and under Colombia's carbon tax. The use of offset crediting mechanisms alongside carbon pricing can have a significant impact on the cost of mitigation and the provision of co-benefits. The potential for offsets to reduce prices has meant that the use of offsets in an ETS is often subject to quantitative limits to reduce its impact on allowance prices.

To establish an offset system, first a reliable crediting mechanism is required for measuring and verifying volumes of emissions reduced, avoided or sequestered. Domestic crediting mechanisms have been established in Australia, California, British Columbia and South Africa, among others. Careful design and regular review of these crediting mechanisms is essential to ensure environmental integrity.

There are four main types of risk that should be considered to ensure the credibility of crediting mechanisms (Climate Change Authority, 2014):

1. **Measurement risk**, where emissions reductions that were measured or estimated did not occur, or occurred to a lesser extent
2. **Additionality risk**, where emissions reductions occurred, but would have happened even without the crediting mechanism
3. **Permanence risk**, where emissions reductions relate to sequestration that did not persist
4. **Leakage risk**, where the project triggered an increase in emissions outside the project.

However, crediting mechanisms often face criticisms regarding these risks. For instance, concerns have been raised regarding provisions to account for leakage from California's offset system (Haya, 2019), and additionality in the Australian system (Burke, 2016).

Supply adjustment mechanisms

Supply adjustment mechanisms (SAMs) are used to seek to better balance supply and demand in an ETS to avoid allowance prices reaching levels that are deemed too high or too low. SAMs aim to reduce price uncertainty for firms considering mitigation investments, and to avoid excessive costs that may have negative social impacts or impacts on competitiveness. By doing so, the introduction of a SAM to an ETS reduces the core distinction between taxes (fixed carbon price) and the ETS (fixed carbon emissions). If maintaining a predictable price signal is a central policy objective, this could be met by either a carbon tax or an ETS with a SAM that tightly constrains prices. However, if reaching a certain emissions level is more important, an ETS with a SAM that loosely constrains prices may be preferred.

All long-standing ETSs have implemented some form of SAM. The EU ETS, California ETS, Québec ETS and RGGI all have SAMs that seek to reduce or increase supply if prices are too high or too low respectively. Table A2.2 provides a high-level description of the mechanisms introduced in carbon markets around the world.

Table A2.2. Supply adjustment mechanisms introduced in example emissions trading systems from around the world

Jurisdiction	Supply adjustment mechanism (SAM)
EU ETS	• Market Stability Reserve (MSR)
New Zealand ETS	• Allowance price ceiling to be replaced with cost containment reserve
California-Québec ETS	• Auction reserve price • Allowance price containment reserve (APCR)
Chinese regional pilots	• Mixed: auction price floors/ceilings and allowance reserves
RGGI (Northeastern US)	• Auction reserve price • Cost containment reserve (CCR) • Emissions containment reserve (ECR) to take effect from 2021
Korea ETS	• Discretionary market interventions • Intention to move to a rule-based system

Source: Authors

There are several types of SAM that can be used; however, most are implemented through the auction system. An auction reserve price in an ETS retains the price flexibility that results from trading but establishes a lower bound, which when it binds acts like a carbon tax. In this way, the price is more predictable (more like a tax), although it is still determined by the market. Auction reserve prices are used in many ETSs, including the California-Québec ETS and the RGGI. Meanwhile, an auction price ceiling can prevent excessively high prices. For instance, California uses a cost containment reserve (a type of SAM) and an auction price ceiling to contain prices (for further information, see Vivid Economics, 2020).

References

Acworth W, de Oca M M, Boute A, Piantieri C, Matthes F C (2020) Emissions trading in regulated electricity markets. *Climate Policy,* 20(1), 60–70. https://doi.org/10.1080/14693062.2019.1682491

Best R, Burke P J, Jotzo F (2020) Carbon Pricing Efficacy: Cross-Country Evidence. *Environmental and Resource Economics,* 77(1), 69–94. https://doi.org/10.1007/s10640-020-00436-x

Bureau of Energy (2019a) *Energy Statistical Annual Report 2019*. https://www.moeaboe.gov.tw/ECW/english/content/ContentLink.aspx?menu_id=1540

Bureau of Energy (2019b) *Energy Statistics Handbook 2018.* https://www.moeaboe.gov.tw/ECW_WEBPAGE/FlipBook/2018EnergyStaHandBook/index.html

Burke J, Fankhauser S, Kazaglis A, Kessler L, Khandelwal N, O'Boyle O, Owen A (2020) *Distributional impacts of a carbon tax in the UK*. London: Grantham Research Institute on Climate Change and the Environment and Vivid Economics. https://www.lse.ac.uk/granthaminstitute/publication/distributional-impacts-of-a-carbon-tax-in-the-uk/

Burke P (2016) Undermined by Adverse Selection: Australia's Direct Action Abatement Subsidies. *Economic Papers: A Journal of Applied Economics and Policy,* 35(3), 216–229. https://doi.org/10.1111/1759-3441.12138

Burke J, Byrnes R, Fankhauser S (2019) *Global lessons for the UK in carbon taxes*. London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science. www.lse.ac.uk/granthaminstitute/publication/global-lessons-for-the-uk-in-carbon-taxes/

Burtraw D, McCormack K (2016) Consignment Auctions of Free Emissions Allowances Under EPA's Clean Power Plan. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2789825

Burtraw D, McCormack K (2017) Consignment auctions of free emissions allowances. *Energy Policy*, 107, 337–344. https://doi.org/10.1016/j.enpol.2017.04.041

Carattini S, Carvalho M, Fankhauser S (2017) *How to make carbon taxes more acceptable*. London: Grantham Research Institute on Climate Change and the Environment and Centre for Climate Change Economics and Policy, London School of Economics and Political Science. https://www.lse.ac.uk/granthaminstitute/publication/make-carbon-taxes-acceptable/

Climate Change Authority (2014) *Carbon Farming Initiative Review*. http://climatechangeauthority.gov.au/sites/prod.climatechangeauthority.gov.au/files/files/CCA-CFI-Review-published.pdf

CPLC [Carbon Pricing Leadership Coalition] (2017) *Report of the High-Level Commission on Carbon Prices*. https://www.carbonpricingleadership.org/report-of-the-highlevel-commission-on-carbon-prices

Doda B, Fankhauser S (2020) Climate policy and power producers: The distribution of pain and gain, *Energy Policy,* 138, issue C, number S0301421519307888

Environmental Information Centre (2015) 催生《溫減法》 立委：「並不完美，但要與時俱進」. https://e-info.org.tw/node/108525

EPA [Taiwan Environmental Protection Agency] (2015) *Greenhouse Gas Reduction and Management Act*. Laws and Regulations Database of the Republic of China. https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=O0020098

EPA (2019a) *2019 Republic of China National Greenhouse Gas Inventory Report*. http://unfccc.saveoursky.org.tw/nir/tw_nir_2019.php

EPA (2019b) 部門別溫室氣體排放管制行動方案. https://ghgrule.epa.gov.tw/action/action_page/52

Feigenbaum E, Hou E-Y (2020) *Overcoming Taiwan's Energy Trilemma*. Carnegie Endowment for International Peace. https://carnegieendowment.org/2020/04/27/overcoming-taiwan-s-energy-trilemma-pub-81645

Haites E (2018) Carbon taxes and greenhouse gas emissions trading systems : what have we learned ? *Climate Policy*, 18(8), 955–966. https://doi.org/10.1080/14693062.2018.1492897

Haya B (2019) *Policy Brief: The California Air Resources Board's U.S. Forest offset protocol underestimates leakage*. https://gspp.berkeley.edu/assets/uploads/research/pdf/Policy_Brief-

US_Forest_Projects-Leakage-Haya_2.pdf

ICAP [International Carbon Action Partnership] (2019) *Emissions Trading Worldwide*. https://icapcarbonaction.com/en/?option=com_attach&task=download&id=614

ICAP (2020) *Korea Emissions Trading Scheme*. https://icapcarbonaction.com/en/?option=com_etsmap&task=export&format=pdf&layout=list&systems%5B%5D=47

IPCC [Intergovernmental Panel on Climate Change] (2018) *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways.* https://www.ipcc.ch/sr15/

Kaufman N, Barron A R, Krawczyk W et al. (2020) A near-term to net zero calternative to the social cost of carbon for setting carbon prices. *Nature Climate Change.* https://doi.org/10.1038/s41558-020-0880-3

Metcalf G (2019) On the Economics of a Carbon Tax for the United States. *Brookings Papers on Economic Activity,* 405–458. https://doi.org/10.2307/26798825

Ministry of Economic Affairs (2019) *Renewable Energy Development Act.* Laws and Regulations Database of the Republic of China. https://law.moj.gov.tw/ENG/LawClass/LawAll.aspx?pcode=J0130032

National Climate Change Secretariat Prime Minister's Office (2016) *Singapore's Climate Action Plan.* https://sustainabledevelopment.un.org/content/documents/154 Climate_Action_Plan_Publication_Part_1.pdf

OECD (2019) *Taxing Energy Use 2019: Country Note – Colombia*. https://www.oecd.org/tax/tax-policy/taxing-energy-use-colombia.pdf

PMR [Partnership for Market Readiness; International Carbon Action Partnership] (2016) *Emissions Trading in Practice: A Handbook on Design and Implementation.* World Bank. https://openknowledge.worldbank.org/handle/10986/23874

Sandbag (2016) *Why does the UK Carbon Price Support matter?* https://ember-climate.org/wp-content/uploads/2016/11/Why_the_Carbon_Price_Support_matters_Nov_2016.pdf

Stavins R (2019) *Carbon Taxes vs. Cap and Trade: Theory and Practice*. Harvard Kennedy School. https://www.hks.harvard.edu/centers/mrcbg/programs/growthpolicy/carbon-taxes-vs-cap-and-trade-theory-and-practice

Venmans F, Ellis J, Nachtigall D (2020) Carbon pricing and competitiveness: are they at odds? *Climate Policy,* 1–22. https://doi.org/10.1080/14693062.2020.1805291

Vivid Economics (2020) *Market Stability Measures: Design, operation and implications for the linking of emissions trading systems*. https://ec.europa.eu/clima/sites/clima/files/ets/reform/docs/study_market_stability_measures_en.pdf

World Bank (2019) *State and Trends of Carbon Pricing 2019*. https://doi.org/10.1596/978-1-4648-0725-1

World Bank (2020) *State and Trends of Carbon Pricing 2020*. https://doi.org/10.1596/978-1-4648-1586-7