PARTNERSHIP FOR MARKET READINESS

CARBON TAX GUIDE

A Handbook for Policy Makers

WORLD BANK GROUP

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LIST OF ACRONYMS

AFOLU	Agriculture, Forestry, and Other Land Use
BAU	Business As Usual
BCA	Border Carbon Adjustment
CCS	Carbon, Capture and Sequestration
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CGE	Computable General Equilibrium (model)
CPI	Consumer Price Index
EITE	Emission-Intensive Trade-Exposed
ETS	Emissions Trading System
EU ETS	European Union Emissions Trading System
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
GATT	General Agreement on Tariffs and Trade
DGP	Gross Domestic Product
GHG	Greenhouse Gas
IEEP	Institute for European Environmental Policy
IPCC	Intergovernmental Panel on Climate Change
NDC	Nationally Determined Contribution
MAB	Marginal Abatement Benefit
MAC	Marginal Abatement Cost
MEB	Marginal Emissions Benefit
MW	Megawatt
MNC	Multinational Corporation
M&E	Monitoring and Evaluation
MRV	Measuring, Reporting and Verification
NAEIS	National Atmospheric Emissions Inventory System
NGO	Non-governmental Organization
NO_x	Nitrogen Oxide
OAIS	Old-Age Insurance System
OECD	Organisation for Economic Co-operation and Development
tCO_2e	Metric tons of carbon dioxide equivalent
PM2.5	Particulate Pollution that is 2.5 micrometers or less in diameter
PMR	Partnership for Market Readiness
RPS	Renewable Portfolio Standard
PRTR	Pollutant Release and Transfer Register
SARS	South Africa Revenue Service
SCC	Social Cost of Carbon
UNFCCC	United National Framework Convention on Climate Change
U.S. REP	United States Regional Energy Policy
VAR	Vector autoregressive (models)
VAT	Value added tax
WBCSD	World Business Council for Sustainable Development
WRI	World Resources Institute
WTO	World Trade Organization

TABLE OF CONTENTS

LIST OF BOXES

LIST OF FIGURES

LIST OF TABLES

Synthesis

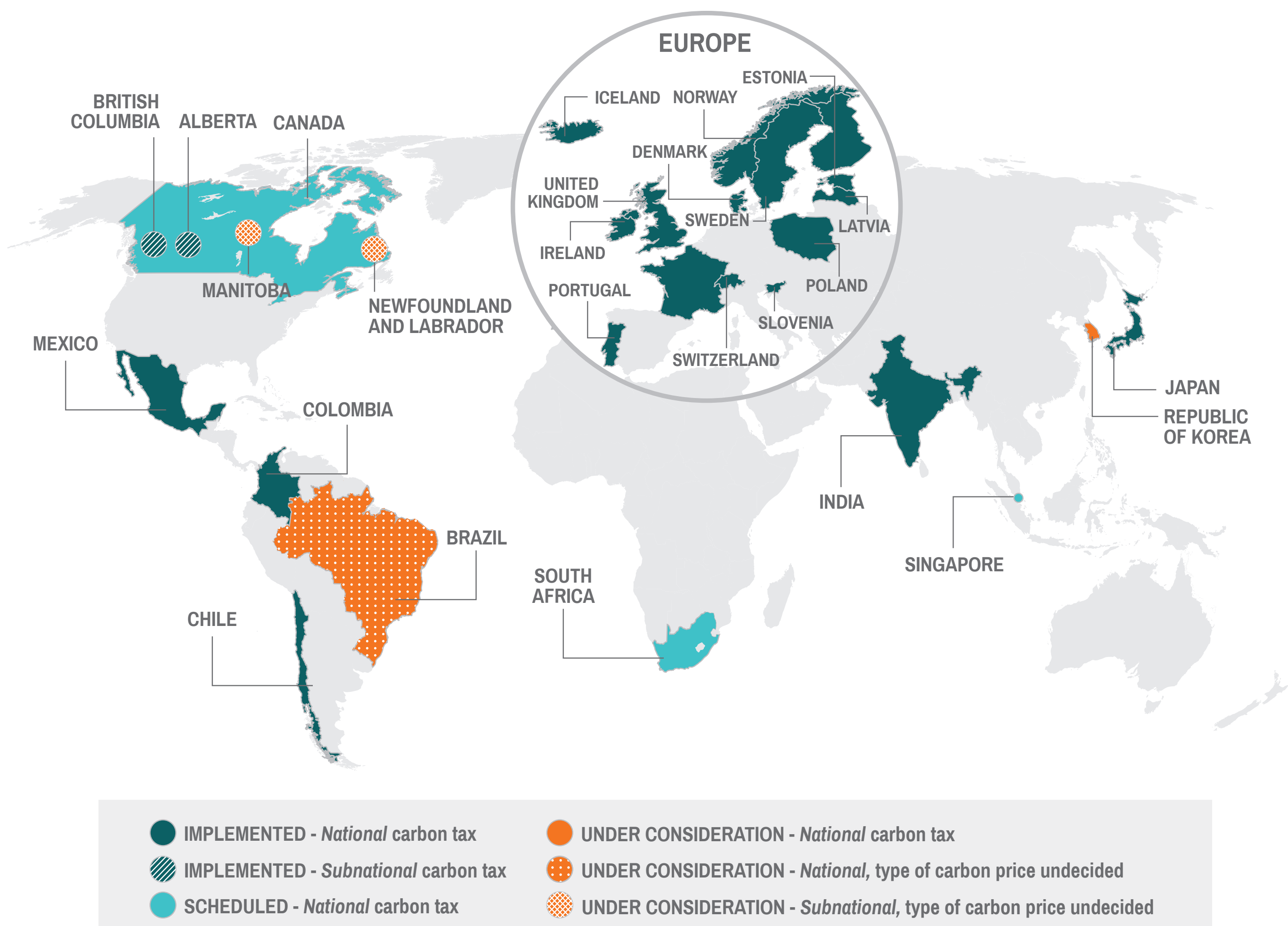
SYNTHESIS: CARBON TAXES IN BRIEF

Recent years have seen renewed and growing interest in policy instruments that put a price on greenhouse gas (GHG) emissions through the adoption of carbon taxes. While up until 2008 only a handful of European countries had adopted explicit taxes on GHG emissions, by February 2017 some 24 countries and subnational jurisdictions—spanning a diverse range of developed and developing countries across five continents—had adopted or were scheduled to adopt a carbon tax (figure 1). As the schemes have multiplied they have become increasingly varied, covering a broader range of sectors and adopting novel features that have shown carbon taxes to be a versatile instrument capable of being adapted to a wide range of policy goals and national contexts.

The resurgence in interest in carbon taxes has come as over three-quarters of the world's nations have developed Nationally Determined Contributions (NDCs) under the Paris Agreement and are increasingly looking for cost-effective ways to turn these goals into actions. It has also developed alongside a gradual shift toward taxes on goods and services, with many jurisdictions seeking to use the tax system to achieve greater economic efficiency and to pursue a range of policy goals beyond raising revenue.

The versatility of carbon taxes also means that it is important for policy makers considering their adoption to have a clear picture of the options available and how those options fit with the jurisdiction's context and policy goals. With this in mind, this Guide provides a practical tool for policy makers and stakeholders in Partnership for Marketing Readiness (PMR) Implementing Countries and elsewhere that (i) helps them determine whether a carbon tax is the right instrument to achieve their policy aims and (ii) supports them in designing and implementing the tax that is best suited to their specific needs, circumstances, and objectives.

Figure 1. Carbon Taxes in Operation, Scheduled, or under Consideration (as of February 2017)



INTRODUCING THE DESIGN PROCESS

Adopting a carbon tax is a significant policy decision, and careful consideration and planning will help ensure the tax is successful in achieving its goals. While some jurisdictions have adopted a carbon tax relatively quickly, others have invested several years in getting the design right, next putting the building blocks in place, and finally bringing the system into operation. How much time is needed will depend, in part, on the type of carbon tax adopted—for example, upstream taxes on fuels generally require substantially less time to develop and implement than downstream taxes, which require additional capacities for measuring, reporting and verification (MRV).

The design process—depicted in figure 2—typically begins with comparing policy options and determining whether a carbon tax would be the right instrument to meet the jurisdiction's policy objectives. At this stage, governments might also consider how the tax would fit in with the jurisdiction's overall climate, as well as with the energy and fiscal policy framework. Where it is decided to adopt a tax, jurisdictions often engage in preparatory work, defining specific policy objectives and thinking about the economic and institutional factors that will inform tax design. At this stage, jurisdictions will usually begin to consult and engage with stakeholders to gain insight into their concerns and priorities.

Moving from preparation to design, there are five central design questions to consider. While each raises its own set of questions and decisions, a whole range of linkages exists between them (lower part of figure 2), and designing the tax as a whole has many advantages. For instance, governments considering what is the right tax rate to support meeting a given emissions target at the same time need to consider which sectors and emissions the tax will be applied to. Similarly, revenue use decisions can be designed to help win the support needed for a broader tax or a higher rate.

Throughout the process, economic modeling can be used to provide insights into the potential impacts of a carbon tax and of different design options on various policy goals. Modeling can also support the process of evaluation and review of the tax, which in turn leads to adjustments in the various design elements based on how the tax performs in practice.

WHEN IS A CARBON TAX THE RIGHT CHOICE?

There are many steps to determining whether a carbon tax is the right choice, including understanding how it works, comparing the carbon tax to other policy instruments, and evaluating various policy instruments in light of specific objectives.

How does a carbon tax work?

Countries and subnational jurisdictions worldwide frequently tax goods and processes that produce GHG emissions. Some of these taxes are general taxes that apply to all goods or activities, such as value-added taxes or corporate taxes, while others apply specifically to carbon-intensive goods, such as excise taxes on fossil fuels. Such taxes—in particular those specifically targeting carbon-intensive goods or processes—may have the effect of incentivizing emission reductions. While in some cases these taxes may be designed with environmental objectives in mind, a carbon tax goes one step further by directly putting a price on GHG emissions.

While they vary in approach, a typical carbon tax establishes a direct link between the GHG emissions (measured in metric tons of carbon dioxide equivalent or tCO_2e) of a product or process and the tax that must be paid on it. This provides a financial incentive for taxpayers to lower their emissions in order to reduce their tax obligations, whether through switching to more efficient practices, choosing cleaner fuels or, in the case of consumers, changing their lifestyle habits. This price per tCO_2e is fixed, though in some cases participants may be given options to reduce their tax obligations, for instance, by purchasing offsets or entering into binding agreements to reduce emissions.

Comparing carbon taxes to other instruments

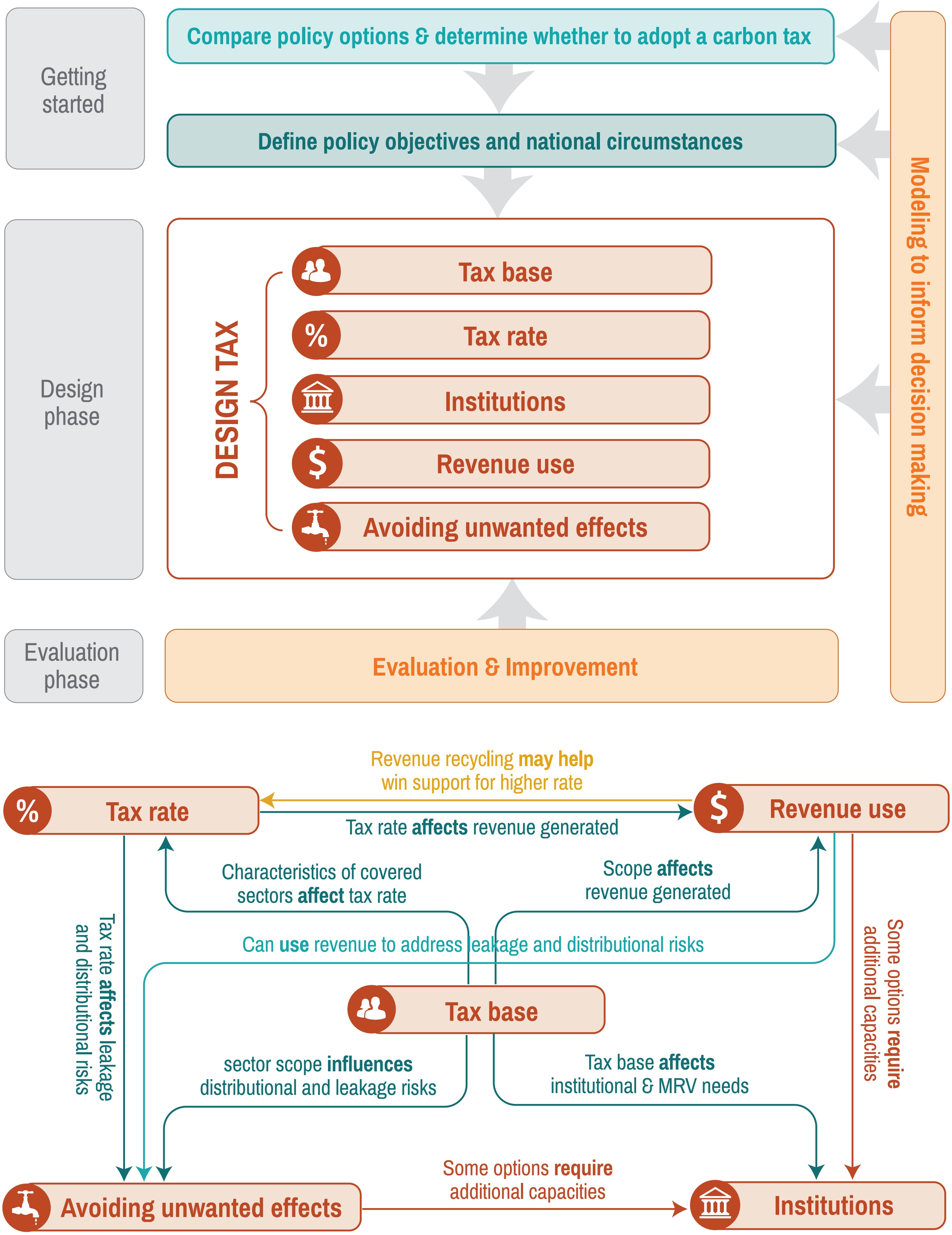
Governments seeking to reduce GHG emissions have a range of instruments at their disposal. In most cases, jurisdictions will adopt a suite of policy measures that seek to address the different characteristics of emitting sectors as well as the different underlying factors causing emissions and preventing mitigation action. To determine whether to adopt a carbon tax as part of this policy mix, jurisdictions need to consider several important questions, outlined below.

What are the characteristics of key emitting sectors?

Carbon taxes are a flexible instrument that can be applied to a broad range of sectors, yet in some sectors applying a tax may be more challenging. Studying the emissions profile of the jurisdiction and understanding the practical implications of applying a carbon tax in the key emitting sectors is therefore an important step in the decision-making process. The economic characteristics of the sector in question—for example, how strongly the economy relies on markets—will also be an important factor in determining whether the price signal is likely to be effective in influencing emitters' behavior.

Synthesis

Figure 2. Stages of Carbon Tax Design and Interlinkages between Design Options



Note: MRV = Measuring, Reporting and Verification.

What are the main barriers to emission mitigation?

Carbon taxes work by putting a price on carbon, and thus are a good choice when aiming to address situations where emitters do not have sufficient incentives to reduce emissions. Where there is a lack of technical mitigation options, carbon taxes can encourage investment in research, but may need to be complemented by other policies that help spur technology development. Where cost-effective mitigation opportunities are already available, on the other hand, non-price based policies may be needed to address the reasons these opportunities are not being capitalized on.

Who should bear the cost of emission reductions?

Like other forms of carbon pricing—and in contrast to command and control regulation—carbon taxes allow emitters to choose how to reduce their emissions, thereby letting them seek out the lowest cost mitigation options. Carbon taxes also require emitters to pay for the costs of mitigating emissions (e.g., by investing in emission reduction technologies) and for their remaining emissions (through tax payments). This means that carbon taxes not only avoid putting a strain on government budgets, but can also be a source of revenue. In that way, a carbon tax differs from policies such as subsidies, where the government compensates emitters for emission reductions and those emitters do not pay for their remaining emissions either—leaving these costs to be borne by society.

Carbon tax or ETS?

Carbon taxes and Emissions Trading Systems (ETSs) have many similarities. Both put a price on carbon, providing a direct financial incentive to mitigate emissions. Both also require emitters to pay for the cost of reducing their emissions and—in the case of ETSs with auctioned allowances—also require them to pay for emissions they do not reduce.[1]

Several important differences also exist between the two. Fundamentally, carbon taxes fix the *price*, while an ETS fixes the maximum *quantity* of emissions. Carbon taxes thereby provide a more stable price signal to investors, and often bring the additional benefit of significantly higher prices. This price holds regardless of other climate and energy policies, making carbon taxes potentially the better choice where governments intend to provide multiple mitigation incentives. Emissions trading, on the other hand, can offer economic efficiency gains by focusing on emission reductions in companies with the lowest mitigation costs, though this benefit assumes well-functioning markets and a sufficient number of participants.

Carbon taxes also have the advantage of not requiring the operation of trading infrastructure, making them relatively easy to administer. This aspect can make them less of a strain on government capacities than an ETS.

Carbon taxes as part of the policy mix

Carbon taxes will typically form part of a larger climate, energy, and fiscal policy mix. Understanding how these policies can complement, overlap with, and counteract each other will facilitate effective policy design.

One important consideration is the interaction of the carbon tax with other relevant taxes (income taxes, corporate taxes, fuel taxes, etc.). Energy taxes on fossil fuels can be particularly relevant since the amount of tax is directly related to the amount of energy used (if not the carbon content of the energy). They therefore combine with carbon pricing instruments to form what the Organisation for Economic Co-operation and Development (OECD) has termed the “effective carbon rate.” In designing a carbon tax, it is useful for governments to consider not only the rate of the carbon tax itself, but the overall effective carbon rate applied to energy.

Other climate and energy policies that might interact with the carbon tax include, for example, government-funded research, renewable energy subsidies, energy and fuel efficiency standards, and technology standards for electricity generation. Many of these can complement the carbon taxes, but ideally the mix of policies will avoid unnecessary overlap, and remove any counteracting incentives.

The role the carbon tax is expected to play within the broader policy mix will also be an important determinant in its design. For example, several jurisdictions have adopted a carbon tax as their “flagship” climate policy, while others have used it to cover emissions not covered by other policies (such as an ETS), resulting in quite a different tax design (in terms of their tax base, tax rate, etc.).

SETTING THE STAGE FOR TAX DESIGN

Once a government has decided to adopt a carbon tax, it may be useful to do some preparatory work before delving into the actual design of the tax. Experience shows that developing a clear picture of policy goals and national circumstances at the outset can lay a solid foundation for informed decision making. Economic models, meanwhile, help provide insights into the potential effects of different design options on key policy objectives.

[1] In the case of both carbon taxes and ETSs with auctioned allowances, liable entities pay for any investments in emission mitigation, and also pay for each tCO_2e of their remaining emissions. This contrasts with ETSs with free allocation, where liable entities have to assume the costs of reducing emissions to the level that is equivalent to the number of allowances they are allocated, but they do not incur a direct cost for the emissions they emit below this level. Nonetheless, in this situation there is an opportunity cost associated with emissions, since if they did not emit they would be able to sell their allowances.

Determine policy objectives

The policy objectives a government seeks to achieve with the tax—for example, GHG emission mitigation, revenue raising, promoting green development, or increasing the efficiency of the tax system—will affect a range of design options. The more specific these objectives are—for example, in terms of emission trajectories or revenue-raising targets—the better governments can design the tax in a way that best meets their objectives. Jurisdictions will typically have multiple objectives, and prioritizing and aligning objectives will often be necessary. Carbon tax modeling (see below) can support decision makers in choosing design options that overall contribute the most to their collective policy objectives.

Understand national circumstances

Carbon taxes will be most effective when they are designed taking into account the specific context of the jurisdiction. Understanding the emissions profile of the jurisdiction and the dynamics and economic structures of key emitting sectors can help in determining where a carbon tax will be most effective. Having a clear picture of relevant capacities and governance constraints also informs decisions on scope, since some designs will require greater and more complex administration than others. At the same time, the level of support for mitigation action among the public, politicians, and key industries may be a factor in deciding which emissions should be included or how high the rate should be set. Moreover, understanding key areas of resistance early on can allow governments to develop ways to overcome them, for example, through revenue recycling and effective communication strategies.

Define principles

When considering design options based on policy objectives and national context, policy makers can make use of a set of principles to help evaluate and inform these different options. While the choice of principles applied in this context will vary for each jurisdiction, a useful starting point is provided by the FASTER Principles for Successful Carbon Pricing (box 1).

Consider using models to support decisions

While many carbon taxes have been adopted without undertaking in-depth economic modeling, where sufficient data and resources are available, models can serve as a valuable tool to help inform decision making—by helping decision makers gain insights into a range of issues that are relevant to carbon tax design (table 1).

Different modeling tools are available to jurisdictions seeking to answer the types of questions listed in table 1. They vary significantly in the approach they take, and each tool has its own strengths and limitations, making it more or less suited to certain questions. An important first step is therefore to identify the specific issues governments want to gain insight into. Where resources and data allow, combining multiple approaches can provide a more complete picture of potential effects.

DESIGNING CARBON TAXES

Designing a carbon tax involves making decisions across a broad range of questions. This Guide presents these decisions under five broad design elements, as summarized

Box 1. The FASTER Principles for Successful Carbon Pricing

The FASTER Principles for Successful Carbon Pricing were developed jointly by the World Bank and the Organisation for Economic Co-operation and Development (OECD), based on the practical experience of different jurisdictions with carbon taxes and Emissions Trading Systems (ETSs). The FASTER Principles are the following:

- **Fairness:** Reflect the “polluter pays” principle and contribute to distributing costs and benefits equitably, avoiding disproportionate burdens on vulnerable groups;
- **Alignment of Policies and Objectives:** Use carbon pricing as one of a suite of measures that facilitate competition and openness, ensure equal opportunities for low-carbon alternatives, and interact with a broader set of climate and non-climate policies;
- **Stability and Predictability:** Implement carbon prices, within a stable policy framework, that give a consistent, credible, and strong investment signal, whose intensity should increase over time;
- **Transparency:** Be clear in design and implementation;
- **Efficiency and Cost Effectiveness:** Ensure that design promotes economic efficiency and reduces the costs of emission reduction; and
- **Reliability and Environmental Integrity:** Allow for a measurable reduction in environmentally harmful behavior.

Table 1. Carbon Tax Design Issues that Can Benefit from Modeling

Issue	How modeling can support decision making
Comparing carbon taxes to other instruments	Assessing relative performance of climate policy instruments Evaluating interactions with other policy instruments and reforms
Evaluating the broad impacts of alternative taxes	Evaluating economic costs/benefits of a given carbon tax design Evaluating distribution of costs and benefits across income groups, geographic regions, and economic sectors Predicting non-GHG environmental benefits Estimating changes in GDP associated with different tax rates Evaluating compatibility with FASTER principles
Determining sectoral responsiveness to carbon tax	Evaluating mitigation potential of technologies and practices Estimating specific changes in economic sectors in response to a carbon tax. Evaluating impact of alternative sectoral coverage arrangements Estimating effects of tax on fossil fuel consumption Forecasting technological changes due to a carbon tax
Estimating effects of tax rate decisions	Estimating emissions responses to different carbon tax rates Estimating revenue arising from different carbon tax rates
Assessing potential effects on leakage and distribution	Estimating the extent of leakage likely to arise from the carbon tax Estimating effects on different income groups or regions Evaluating the effectiveness of mitigation measures
Modeling the effects of options for revenue use	Estimating current marginal cost of public funds and relative marginal cost of various types of tax Estimating economic value of substituting a carbon tax for other taxes
Analyzing expost impacts	When conducting an expost analysis of the impacts of the carbon tax, many of the issues listed above could be addressed retrospectively rather than prospectively.

Table 2. Checklist for the Five Steps of Carbon Tax Design

Define the tax base	Determine the tax rate	Address potential undesirable effects	Determine use of revenues	Ensure oversight and compliance
✔ Decide which sectors to cover ✔ Decide which gases to cover ✔ Choose the points of regulation ✔ Choose the entities to regulate and set thresholds (if relevant)	✔ Determine the basis for setting the tax rate ✔ Determine how the rate will develop over time ✔ Consider using modeling to predict the effects of different tax rates on meeting policy objectives	✔ Assess the risk of the tax leading to carbon leakage or producing negative distributional effects ✔ Consider the costs and benefits of adopting measures to mitigate risks ✔ Consider the costs and benefits of different measures ✔ Develop criteria to determine eligibility for assistance measures (if relevant)	✔ Calculate projected revenue from the carbon tax ✔ Determine whether to redistribute revenues, lower income taxes, increase spending, or to do all three ✔ Decide whether to allow offsets	✔ Map the required roles and functions for administering the tax ✔ Determine whether these roles and functions can be carried out with existing capacities or require new roles to be defined and different capacities ✔ Establish clear procedures and ensure coordination of key entities ✔ Include clear and meaningful penalties for noncompliance

in table 2. As indicated in figure 2, many of these decisions are linked, and so it is important to step back and consider how the different options fit together and, to the extent possible, aim to decide on an integrated tax design rather than making piecemeal decisions on individual questions.

Define the tax base

- ✔ Decide which fuels and sectors to cover
- ✔ Decide which gases to cover
- ✔ Choose the points of regulation
- ✔ Choose the entities to regulate and set thresholds (if relevant)

The tax base of a carbon tax refers to the fuels, sectors, and specific entities that are liable for paying the carbon tax. Defining the tax base is among the first and crucial decisions to be made in designing a carbon tax. How the base is defined will affect the degree of emission reductions that can be achieved, the amount of revenue that can be raised, and the industries and groups that will be affected by the tax. It also has implications for every other major decision that needs to be made in relation to carbon tax design, from the tax rate that will be needed to achieve a given emission or revenue target to the kind of institutional arrangements required to implement the tax.

Though the tax base can be defined in many ways, a basic distinction can be drawn between so-called upstream and midstream taxes on the production, import, and sale of fossil fuels, and those on direct emissions (whether based

Table 3. Coverage of Selected Existing and Planned Carbon Taxes

TAXES ON FUELS		
JURISDICTION	**FUEL COVERAGE**	**MAJOR EXCLUSIONS[a]**
British Columbia	All	Agriculture, international aviation, and maritime transport
Denmark	All	EU ETS sectors, international maritime
France	All	EU ETS sectors, agriculture, commercial transport
India	Coal	Not applicable
Ireland	All	EU ETS sectors, agriculture, international maritime transport
Japan	All	Agriculture; forestry; air, rail, and maritime transport
Mexico	Coal, oil[b]	Not applicable
Norway	Oil, gas	EU ETS sectors, international maritime transport; fishing and agriculture (partially excluded)
Portugal	All	EU ETS sectors, international maritime transport
Sweden	All	EU ETS sectors, agriculture (partially excluded), international maritime transport
Switzerland	All	Transport; Swiss ETS-covered companies
United Kingdom	All	EU ETS sectors, agriculture (partially excluded), international maritime transport
TAXES ON DIRECT EMISSIONS[c]		
JURISDICTION	**EMISSIONS COVERED**	
Australia (former)	Electricity generation, industry, waste, fugitive emissions	
Chile	Large boilers and turbines	
South Africa[d]	Fossil fuel combustion, industrial processes, product use, fugitive emissions	

Note: EU ETS = European Union Emissions Trading System

a. This column indicates the most important exclusions for each carbon tax. For a more detailed description of the coverage and major exemptions of each tax, see table 16 and the technical appendix.

b. Includes coverage of oil products.

c. Taxes on direct emissions can typically be more precisely targeted to certain sectors and other emissions sources, and so it is less common to have major exclusions than it is for upstream taxes, where a tax is levied on a fuel that may be used for a number of purposes. More specific exclusions to taxes on direct emissions are listed in table 16 and the technical appendix.

d. In addition to applying the tax directly to emitters in the sectors mentioned, South Africa also intends to apply an upstream fuel tax to cover transport emissions.

on fuel or not) such as those from electricity generation, industrial processes, and waste disposal. Taxes on fossil fuels are typically the most straightforward, since most jurisdictions can "piggyback" on existing systems for administering excise taxes. To date, they have also been the most common (table 3). These kinds of carbon taxes often require minimal additional administration and do not require MRV of emissions. Furthermore, the identification of the entity legally responsible for the tax typically follows existing excise tax rules.

Taxes on direct emissions may require more administration and building additional capacities for MRV, but may also allow for targeting a broader scope of emissions in certain jurisdictions. Since they generally require creating new administrative structures or at least adapting existing structures, they also raise a number of additional questions, such as where in the supply chain to apply the tax, which legal entity to make liable, and whether to apply thresholds. Jurisdictions seeking to ensure the broadest possible coverage of emissions can apply elements of both systems—for example, by applying a direct tax to emissions of large installations and an upstream tax on fuel used by dispersed sources such as vehicles and buildings.

Lessons learned

All else being equal, broader taxes will typically maximize emission mitigation and revenue-raising potential, and be more cost-effective. At the same time, which option (or combination of options) works best in a given jurisdiction will depend on factors such as the emissions profile of the jurisdiction; existing and planned climate, energy, and tax policies; the structure of key sectors; and government capacities for tax administration and MRV.

Jurisdictions that have an existing ETS have tended to adopt carbon taxes to cover much of their non-ETS emissions, though some have also used the carbon tax to apply a price floor to ensure some level of price stability in their ETS-covered sectors. Jurisdictions using the carbon tax as their "flagship" policy have sought to make coverage as broad as possible which, at least in the case of jurisdictions with a significant share of non-fuel emissions, will often mean designing a stand-alone tax system that directly targets emissions.

Determine the tax rate

- ✔ Determine the basis for setting the tax rate
- ✔ Determine how the rate will develop over time
- ✔ Consider using modeling to predict the effects of different tax rates on meeting policy goals

Setting the tax rate is among the most important decisions facing jurisdictions when they adopt a carbon tax. This involves two major elements. First, policy makers have to choose the basis for setting the original carbon tax rate, and then they have to decide whether to set a trajectory for future prices or adopt a specific mechanism for adjusting the rate over time.

Four main approaches can be taken to setting the original carbon tax rate, each of which is linked to different policy objectives. Governments can set the tax rate so as to seek a certain level of emission mitigation, to raise a certain level of revenue, or to reflect the social costs of emissions. In each of these three approaches, models can be used to help determine the rate that will help achieve a specific objective. In addition, jurisdictions can develop benchmark according to tax rates in jurisdictions with similar circumstances or those jurisdictions who are competitors in key commodities affected by the tax. Alternatively, jurisdictions that have an ETS may choose to make a link between the carbon tax rate and the ETS price, for example, by setting a limit on the differential between them at any given time.

Several options are available to determine how the rate will develop over time, among others, defining a trajectory for the price over a given period, building in a rate adjustment formula, and making the rate subject to periodic review by experts, policy makers, and other stakeholders. Which of these options are actually available will partly depend on jurisdictions' constitutional contexts.

Lessons learned

Practice has seen jurisdictions adopting a wide range of tax rates—ranging from US$3 to US$168 per ton of CO_2e (table 4)—and jurisdictions will need to consider their policy goals as well as their economic, social, and political context in determining the rate that will work for them. A range of jurisdictions have sought to set rates that achieve a certain level of emission abatement or raise a certain amount of revenue, and several have used some form of benchmarking to inform the tax rate.

Given the often broad range seen in estimates of the social cost of carbon (SCC), to date few jurisdictions have used this cost component as the basis for their carbon tax rate. On the other hand, jurisdictions do use the SCC estimate for other policy decisions, and there is a convincing argument for at least using these estimates to determine the range of prices that can be considered economically efficient.

In all cases, the approach taken is often only used as a starting point, and in most cases the final rate is determined as part of a political process that balances multiple policy objectives. Most jurisdictions have started with a relatively low rate and increased it over time. This has been highlighted as an important factor in gaining support for the tax and providing industries and consumers time to adapt their behavior to the price signal, as well as being economically efficient. Where possible, defining the trajectory of the tax rate—at least in broad terms—or linking the rate to external factors such as progress in meeting emission reduction targets helps to provide the certainty needed to foster investments in low-carbon technologies. Opting for a variable rate can also be valuable where rate increases would otherwise require new legislation or be subject to challenging political processes.

Table 4. Examples of Carbon Tax Rates for 2015

JURISDICTION	PRICE IN 2015 ($US\$/tCO_2e$)
British Columbia	22
Chile	5
Denmark	31
Finland	48–83
France	24
Iceland	10
India	6
Ireland	28
Japan	3
Mexico	1–4
Norway	4–69
Portugal	5
South Africa	8.50[a]
Sweden	132[b]
Switzerland	87
United Kingdom	16

Note: US$ = U.S. dollar; tCO_2e = metric tons of carbon dioxide equivalent.

a. This rate is the "headline" rate for the South African carbon tax. In the first phase of the tax, liable entities are allocated tax-free allowances of 60–95%, meaning that the effective tax rate paid by liable entities will be significantly lower than the headline rate.

b. Sweden currently still applies a lower tax rate to industrial, agricultural, forestry and fisheries operations than to households and the service sector. However, from 2018 on, the industry rate will rise to the same level as the general rate, and for that reason only the general rate is shown here.

Avoiding undesirable effects of the carbon tax

- ✔ Assess whether the carbon tax risks causing leakage or undesirable distributional impacts
- ✔ Consider costs and benefits of adopting measures to address these impacts
- ✔ Define mitigation measures
- ✔ Develop tests for determining eligibility, and consider whether to link eligibility to performance

Carbon taxes may sometimes have effects that were not intended as part of their design, such as causing carbon leakage—where emissions in the taxing jurisdiction are offset by an increase in emissions in jurisdictions without equivalent climate policies in place—or disproportionately affecting low-income groups or certain geographical regions. The extent to which these risks arise depends on a range of factors and in many cases will be limited. Nonetheless, the these risks are important political concerns and should at least be considered during the carbon tax design process.

Models can be useful in predicting potential leakage or distributional impacts, though they are also subject to uncertainty and should only be used as an overall guide. Econometric, ex post evaluations can also be used to assess impacts in practice, helping to inform periodic adjustments to measures designed to address undesirable effects. Jurisdictions can also adopt a set of criteria to determine whether specific sectors, companies, or population groups qualify for special support measures. In the case of leakage, most jurisdictions have focused on the emissions intensity of a given economic activity and the exposure of the sector to international trade, though including other factors such as the level of carbon prices in other jurisdictions can help provide a more robust assessment of that risk. Eligibility for distributional reasons will in many cases be linked to existing categories within the welfare system.

If jurisdictions determine that significant risks of leakage or negative distributional impacts exist, several measures can be adopted to mitigate those risks (table 5). What measure is chosen has important implications for the effectiveness of the tax. The most commonly used are measures that reduce tax contributions, such as exemptions, rebates, and offsets, or provide in-kind support, such as subsidies. These measures can be applied to address both leakage and distributional concerns. Other measures that have been discussed specifically in relation to addressing leakage—but have not yet been applied in the carbon tax context—include border measures to extend the tax to imports and/or rebate it for exports; and reciprocal carbon price floor arrangements that reduce or eliminate the price differential with competing jurisdictions.

Table 5. Typology of Measures to Address Leakage and Distributional Risks

		MEASURE	EXAMPLES
Measures addressing leakage and distributional risks	Reducing carbon tax payments	Exemptions	British Columbia, Japan, Switzerland
		Reduced tax rates	Sweden, France
		Rebates on carbon tax payments	Denmark, Ireland, Finland
		Offsets	Mexico, South Africa
	Support measures	Output-based rebates	Sweden NO_x tax
		Support programs (e.g., subsidies)	South Africa, Ireland, Switzerland, Japan
		(Non-carbon) tax reductions	British Columbia, France
		Flat payments	Australia
Measures addressing leakage only	Border adjustments and consumption-based taxation		California ETS
	Tax coordinating measures		None

Lessons learned

Significant evidence has yet to be uncovered of leakage occurring under carbon pricing schemes in practice. Other business costs are typically far more significant determinants of competitiveness than carbon pricing. There is somewhat more evidence that carbon taxes can have negative distributional effects, though this strongly depends on the context—in some jurisdictions the distributional effects of a tax may in fact be positive. The relevance of leakage and distributional risks will depend, among other things, on the emissions the carbon tax is applied to. In the case of carbon taxes on transport and residential energy use, distributional concerns will usually be more relevant, while for taxes on heavy industry, leakage will tend to be more relevant.

Given that measures to address leakage and distributional risks are often costly and can themselves reduce the environmental effectiveness of the carbon tax, it is worthwhile for jurisdictions to closely examine possible risks before deciding to adopt measures and, where they do adopt them, define strict eligibility criteria to avoid applying them too broadly. It is also important to carefully consider which measures are more effective. Measures that exempt or reduce the amount of carbon tax paid by certain entities essentially eliminate or reduce the price signal, and are therefore highly detrimental to the environmental effectiveness of the tax. Linking support measures to other factors such as outputs or the adoption of clean technologies are often more environmentally effective approaches.

Determine use of revenues

- ✔ Calculate projected revenue from the carbon tax
- ✔ Decide whether to redistribute revenues, lower income taxes, increase spending, or do all three
- ✔ Decide whether to allow offsets

Carbon taxes can raise significant revenue, and how the revenue will be used can have profound implications for the overall economy, the efficiency of the tax system, and public welfare. Broadly speaking, governments can use three strategies to decide how to use carbon tax revenue: (i) revenue neutrality, (ii) increased spending (including on debt reduction), and (iii) forgoing revenue by permitting entities to surrender offsets in lieu of tax payments.

In its simplest form, revenue neutrality can be achieved by returning revenues to households and businesses through direct rebates. The latter can be provided equally to each taxpayer or targeted at specific groups such as low-income households or trade-exposed businesses. Revenue neutrality can also be achieved by using the revenue to reduce other taxes such as labor or corporate taxes. This approach is commonly considered the most economically efficient way to use carbon tax revenue, although in some contexts increasing spending or lowering public debt can also have important economic advantages.

Where governments decide to use revenue to increase spending, they may direct it toward the general budget or earmark it for specific purposes such as supporting environmental programs or increasing welfare support. Even funds deposited in the general budget may eventually be used for specific purposes linked to the tax. Other jurisdictions may use the funds for reducing the deficit or paying off national debt.

Governments can also decide to forgo part of their revenue by allowing taxpayers to surrender offsets as a substitute for paying (part of) their carbon tax obligations. Where domestic offsets are used, this has the effect of redirecting funds from the government (tax revenues) or sectors covered by the tax to uncovered sectors (investment in emission mitigation), though how much funding will eventually be invested in uncovered sectors will depend on a range of factors, particularly the offset price.

Lessons learned

In practice, jurisdictions have employed a wide range of approaches to revenue use and many have combined multiple approaches according to policy needs and priorities (table 6). Revenue recycling by reducing other taxes has been widely used by jurisdictions drawn to the economic efficiency of the approach and the potential it provides to reduce more distortionary taxes such as those on capital investments and labor. Increased spending can heighten the environmental impact of the tax where the revenue is directed to supporting climate programs or incentives. While in many countries direct earmarking of funds is not permitted, funds can also be directed to specific uses through agreements linked to the budget process. There is as of yet no practical experience with the use of offsets under a carbon tax, though a number of jurisdictions are developing rules to allow offset use under their systems.

Tax revenue has in some cases been used to help increase support for the tax among the general public and industry stakeholders, either through tax cuts, rebates, or support programs. For this to be effective, it is important to have clear communication on how the revenue is being used. It is also important to consider timing here—governments can help consolidate support by committing to providing certain benefits upfront and clearly linking their continuation to the revenue generated through the carbon tax.

Ensure oversight and compliance

- ✔ Map the required roles and functions for administering the tax
- ✔ Determine whether required roles can be carried out with existing capacities or if new roles and capacities are needed
- ✔ Establish clear procedures and ensure coordination of key entities
- ✔ Include clear and meaningful penalties for noncompliance

Effective tax administration requires effective institutions and processes to implement the tax and enforce compliance with tax obligations. Downstream taxes on direct emissions will also require the development of systems for the accurate MRV of emissions. Jurisdictions invariably already have a revenue collection framework and a revenue body in place. To the extent possible, jurisdictions can also seek to align the administration of a carbon tax with existing frameworks and institutions. Carbon taxes that cover direct emissions and those that adopt additional design features, such as offsets, or link exemptions or rebates to emission reduction agreements may, however, need to develop additional capacities.

For upstream taxes, emissions are typically estimated based on fuel sales, avoiding the need for specific MRV, while taxes targeting direct emissions will typically need to establish more complex MRV systems. Where possible, jurisdictions can seek to build on existing systems, either those that already measure GHG emissions or those that monitor other relevant factors such as energy and industrial outputs.

Existing systems for ensuring compliance with tax obligations—including audit procedures and penalties for nonpayment—will also often be used for enforcing the carbon tax. At the same time, compliance can also be encouraged in the design of the tax itself, for example, through simplicity and transparency, and matching design with government capacities.

Lessons learned

What are the right institutional arrangements depends on the scope of the tax, how it is designed, and the existing legal and administrative context of each jurisdiction. One of the advantages of carbon taxation as a policy option is that jurisdictions will already have a revenue collection framework and a revenue body in place, providing a solid basis upon which to build. At the same time, often multiple government and nongovernment entities will be directly or indirectly involved in designing, implementing, and evaluating the carbon tax—particularly if it has a relatively broad scope—and so coordination is of key importance.

EVALUATE OUTCOMES AND REVIEW

Carbon taxes are often characterized by "learning by doing," and getting the design right will often require jurisdictions to make adjustments over time. As such, after implementation of a carbon tax, jurisdictions should plan to conduct reviews of program performance and impacts. They may also choose to build procedures for adjustments into the process.

Table 6. Revenue Use in Selected Jurisdictions

JURISDICTION	USE OF CARBON TAX REVENUE
Australia	Assistance for low-income households, including income tax reform Jobs and competitiveness package Compensation to coal-fired electricity Use of offsets Clean Energy Finance Corporation (a green bank)
British Columbia	Income tax reductions and credits Property tax reductions and credits
Chile	General budget, intended for spending on education and health
Denmark	Reduced income taxes and employer's pension and social insurance contributions Energy efficiency and environmental programs
Finland	Reduced income taxes and employer's social insurance contributions General budget
France	Reduced income and corporate income taxes Energy assistance to low-income households
Iceland	General budget
India	Clean energy and environment
Ireland	General budget / deficit reduction / debt payments
Japan	Promotion of low-carbon technologies
Mexico	General budget Use of offsets
Norway	General budget Reduced income and capital taxes Pension plan for low-income individuals
Portugal	Income tax reductions for low-income households General budget
South Africa	Electricity levy reduction Support for energy efficiency and renewable energy Support for public transport and rail freight transport Use of offsets
Sweden	General budget Reduced income and corporate taxes
Switzerland	Reduced health insurance and social security contributions Energy efficiency in buildings Technology fund
United Kingdom	General budget

Different types of review exist and each has its role in the policy-making process. Impact evaluations assess the performance of the tax and support the other reviews; comprehensive reviews are designed to amend fundamental elements of the carbon tax; and regular reviews are meant to amend administrative or technical elements of the carbon tax. Jurisdictions will often try to design impact evaluations to feed into comprehensive reviews and allow for evidence-based decision making. Jurisdictions should also identify a process for making adjustments where needed. Minor adjustments may be delegated to administrative authorities or even programmed to occur automatically, while more substantial adjustments might be reserved for legislators.

In defining this review process, policy makers will need to balance the following: (i) retaining flexibility to modify the program as the need arises; and (ii) providing the kind of predictability that facilitates decision making for covered entities. Systems with clearly defined processes and responsibilities for review and adjustment will tend to provide "predictable flexibility."

CAPITALIZING ON CARBON TAXES' POTENTIAL

Recent years have seen carbon taxes solidify their position among the foremost policy instruments for addressing climate change. Experience over the past two and half decades has shown that, when designed well, they not only provide a powerful and efficient tool for reducing GHG emissions, but can also raise substantial government revenue and help achieve a range of economic and development benefits. Meanwhile, the increasing diversity of designs that has emerged highlights that carbon taxes can be molded to fit each jurisdiction's particular legal, economic, and social context, and to fulfill different roles within its overall climate, energy, and fiscal policy mix.

As countries begin to move toward implementation of NDCs assumed under the Paris Agreement, the momentum on carbon taxes seems likely to continue. As an increasingly diverse range of countries and subnational jurisdictions design new carbon taxes—and those with existing taxes continue to improve and adapt—we can expect to see a rich landscape of designs and innovations. These experiences will in turn inform other jurisdictions' efforts, leading to a collective process of continuous improvement in which the potential of carbon taxes to fulfil climate, development and fiscal policy objectives is capitalized upon.

Beyond collective learning, greater coordination on carbon pricing also has the potential to increase their effectiveness in meeting policy objectives. Such cooperation could provide the conditions that allow governments to adopt carbon prices that are comprehensive and provide ambitious price signals that incentivize the transformational shifts in investment patterns needed to move toward truly low-carbon development paths.

1 INTRODUCTION

1.1 BACKGROUND: GROWING INTEREST IN CARBON TAXES

In November 2016, the Paris Agreement entered into force, becoming the first international agreement to commit all signatory countries to collective action on mitigating climate change. The Agreement requires all Parties to undertake "ambitious efforts" to mitigate greenhouse gas (GHG) emissions,[2] marking an enormous step forward from its predecessor, the Kyoto Protocol, which limited mitigation to several dozen developed countries. Built on a bottom-up approach, the Paris Agreement allows each country to define its own mitigation contribution. By October 2016, 189 countries had submitted Nationally Determined Contributions (NDCs) setting out their intended mitigation efforts, with 80 percent of these adopting some form of mitigation targets (FAO 2016).

Countries have a wide range of instruments at their disposal to meet the targets set out in their Nationally Determined Contributions (NDCs). Many countries, both developed and developing, have already adopted policies to address climate change, with the policy mix in each case reflecting factors ranging from the specific emissions profile of the jurisdiction in question to its political, economic, and legal contexts. In the wake of Paris, there is now enhanced focus on developing policy frameworks that can deliver reliable, long-term emission reductions on a large scale. To achieve this goal, a growing number of jurisdictions are turning to carbon pricing, either through Emissions Trading Systems (ETSs) or, increasingly, carbon taxes.

Originally introduced in the early 1990s as one of the first instruments explicitly designed to reduce GHG emissions, recent years have seen a renewed interest in policy instruments that put a price on carbon through the application of taxes. While up until the early 2010s only a handful of European countries had adopted carbon taxes, by 2015, 4 percent of annual global GHG emissions were covered by explicit carbon taxes, and several other countries had scheduled the introduction of further carbon taxes in the coming years (World Bank and Ecofys 2015).[3]

[2] Paris Agreement, Article 3.

[3] At the time of writing, 12 Partnership for Market Readiness (PMR) Participants (implementing or contributing countries or technical partners) have scheduled or are implementing a carbon tax.

This renewed interest is notable not just for its scale, but also because of the broad range of geographies and sectors represented in recent carbon taxes. Previously the domain of advanced economies, carbon taxes have in recent years been adopted or tabled in developing countries across Africa, Asia, and Latin America. And while early carbon taxes focused exclusively on the purchase and sale of fossil fuels, recent efforts have encompassed an increasingly diverse range of sectors such as electricity generation, and waste and industrial processes. Several of these taxes incorporate elements of ETSs, and may even be designed bearing in mind the possibility that they'll be converted to an ETS in the future.

1.2 PURPOSE OF THIS GUIDE

This Guide has a dual purpose: (i) to provide policy makers and other policy leaders and influencers with a practical tool to help them determine whether a carbon tax is the right instrument to achieve their policy aims; and (ii) to support them in designing and implementing the carbon tax best suited to their specific needs, circumstances, and objectives. Developed within the Technical Work Program of the Partnership for Market Readiness (PMR), it draws on the rich experience of PMR participants, and other countries and subnational jurisdictions that have developed carbon taxes to provide pragmatic guidance on the implications, benefits, and drawbacks of different approaches.

The Guide is expected to be equally relevant to high-level policy makers and legislators, and technical experts in governments, the private sector, NGOs, or international organizations who are directly or indirectly involved in the design and implementation of carbon taxes. Each chapter contains a high-level, summary of the main issues, for the benefit of policy makers. The more technical issues are addressed in "Technical Notes" included throughout the document, and references and further reading suggestions are provided for those seeking a more in-depth discussion of relevant issues.

1.3 HOW TO USE THIS GUIDE

The Guide is divided into three parts:

- **Getting Started.** Part 1 focuses on understanding what carbon taxes are and the role they can play in your jurisdiction's climate mitigation and energy and economic policies (chapter 2). This part of the Guide also addresses the national context and circumstances that will influence both the suitability of carbon taxes in your jurisdiction (chapter 3) and the use of models to assess the likely impacts of a tax and determine which design options will be most effective in the specified setting (chapter 4).

- **Designing Carbon Taxes.** Part 2 provides detailed guidance on each of the key steps involved in designing and implementing carbon taxes, more specifically, the tax base (chapter 5), the tax rate (chapter 6), measures to address unwanted effects (chapter 7), the use of revenue (chapter 8), and oversight and compliance (chapter 9). Each chapter first gives an overall introduction to the topic, next sets out the various options available, and finally offers practical guidance on choosing the right options for your jurisdiction.
- **Evaluating Policy Outcomes.** Part 3 goes on to explore the role that monitoring and evaluation (M&E) can play in improving the functioning and effectiveness of your carbon tax over time. It provides guidance on how to take into account the results of M&E processes so as to better tailor the carbon tax to your jurisdiction's goals and circumstances.
- **Technical Appendix.** This appendix includes detailed case studies of a selection of existing carbon taxes that were prepared as part of the research for this Guide. The case studies delve into the detailed workings of each of the carbon taxes included, and provide a summary of the successes experienced and challenges faced. The appendix is available as a separate report to the main guide.

The text focuses on explaining the main issues regarding each aspect of carbon tax design, identifying the options available to policy makers, and discussing the implications and the strengths and weaknesses of different options. Special attention is paid to highlighting which design options may be effective in achieving specific policy objectives and how to choose the right options in the context of national circumstances.

Throughout the text, examples of jurisdictions that have applied the approaches discussed are provided, while more detailed case studies contained in text boxes zoom in on specific experiences and lessons from existing practice. Full case studies that were prepared with background information on a wide range of carbon taxes are included in the technical appendix. These case studies are based on desk review and interviews, questionnaire responses, and peer reviews by government policy makers in most of the jurisdictions concerned.

The present Guide provides a starting point for understanding the various steps in design and implementation of a carbon tax, the options available, and how these options relate to different circumstances and objectives. However, many of the issues involved are complex and effectively designing a carbon tax will often require much more in-depth analysis and thinking. To facilitate this pursuit, each section contains a list of further materials to help you better understand the topics and make more fully informed choices. Reference is also made to other PMR publications and technical notes that cover in more detail some of the issues discussed here.

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PART I

GETTING STARTED

2 DECIDING WHETHER TO ADOPT A CARBON TAX

At a Glance

A carbon tax is a tax that explicitly places a price on greenhouse gas (GHG) emissions or that uses a metric directly based on GHG emissions. First adopted in Scandinavia in the early 1990s, recent years have seen renewed and growing interest in carbon taxes from developed and developing countries alike. This has led not only to a significant increase in the number of carbon taxes implemented worldwide, but also in their diversity in terms of regional scope, sectoral coverage, and design, producing a wealth of experience for jurisdictions to build upon.

Of course, a carbon tax is just one of many policy instruments that jurisdictions can employ to reduce GHG emissions, with different instruments addressing different barriers to mitigation action. From a mitigation perspective, carbon taxes are designed to address the lack of adequate incentives for private entities to reduce emissions. Other instruments can also address this issue, including emissions trading systems (ETSs), subsidies, and command and control regulation. These instruments can be differentiated by two main factors:

- **The extent of discretion for private parties.** Some of the instruments, such as carbon taxes, ETSs, and results-based subsidies, are linked to outcomes and so provide private parties with room for innovative action. Others, such as technology standards, require specific actions and so provide little room for innovation by private entities.
- **The distribution of costs.** Different instruments distribute both the cost of mitigation actions and the societal costs associated with remaining emissions in different ways. Carbon taxes require covered entities to pay for abatement and pay a price for the unabated emissions.

Studies have shown carbon taxes are among the most efficient policy instruments available to mitigate climate change. Carbon taxes can also be designed to generate a number of other important benefits, such as raising revenue, internalizing the social costs of emissions, and increasing the efficiency of the tax system. Nonetheless, as with any policy instrument, their suitability for a given jurisdiction will depend on a number of context-specific considerations, for example, the extent to which the local economy works through prices and markets. Liable entities that are not accustomed to responding to price signals might not respond efficiently or effectively to a carbon tax.

Upstream carbon taxes on fuel require relatively little administration while downstream taxes on emissions require a good deal more. In jurisdictions with lower capacity, the suitability of a tax depends on whether an upstream tax would cover the main sources of emissions. In all cases, it is important to consider the multiple potential interactions between the carbon tax and other elements of the tax system, as well as with other climate, energy, and development policies. It is worthwhile for jurisdictions to carefully analyze these interactions and consider what complementary policy changes might have to be implemented to ensure that the carbon tax is effective in meetings its goals.

2.1 INTRODUCTION

Carbon taxes are one of a broad range of policy instruments designed to reduce GHG emissions. When considering whether they are the right instrument for pursuing GHG mitigation or other goals, it is helpful for jurisdictions to compare them to the other instruments that can be used for meeting the same goals, and consider their respective strengths, weaknesses, and implications. It is equally important to consider how carbon taxes relate to other climate policies, as well as to other taxes, in order to create smart climate policy and fiscal policy mixes, respectively.

This chapter introduces carbon taxes and guides policy makers in understanding how they work and how they compare with other policy instruments designed to reduce GHG emissions and achieve related development objectives. Section 2.2 gives an overall introduction to carbon taxes, distinguishes them from other taxes, and provides a brief history of their use. Section 2.3 goes on to introduce the different types of instruments that can be used to achieve climate change mitigation and compares carbon taxes to the other options, considering the different barriers to mitigation they address and how they differ in terms of flexibility and cost distribution. Section 2.3 also considers how carbon taxes interact with other climate policies and other fiscal policy instruments.

2.2 INTRODUCING CARBON TAXES

Carbon taxes place a price on GHG emissions by taxing goods or activities based on the emissions they produce. This gives taxpayers a financial incentive to lower their emissions in order to reduce their tax obligations. In the case of industry, a carbon tax might induce investment in cleaner technology or switching to more efficient practices. Consumers may be incentivized to invest in energy efficiency, change their lifestyle habits or, where the option is available, switch to cleaner forms of energy. In liberal energy markets where additional costs are passed on to consumers, carbon taxes may also lead to increased consumer and industry demand for renewable energy, helping spur investments in wind, solar, and hydro. At the same time, carbon taxes create a source of revenue for governments, which can be used to increase government spending or reduce other taxes.

2.2.1 Defining carbon taxes

It is common for countries and subnational jurisdictions worldwide to tax goods and processes that produce GHG emissions. Apart from general taxes applicable to all goods (e.g., value added tax) or activities (e.g., corporation tax), a range of taxes apply specifically to carbon-intensive goods, in particular excise taxes on fuels and electricity taxes. Such taxes may have the effect of disincentivizing emitting activities, and are understood to be included in the "effective carbon rate" applied to energy and energy products.[4]

In contrast to general taxes on energy, carbon prices are one of a number of policy instruments that seek to mitigate climate change by placing a direct price on GHG emissions. And in contrast to other carbon pricing mechanisms such as ETSs, carbon taxes place a fixed price on a given unit of GHG emissions. This is typically done by levying a tax on fossil fuels in accordance with their carbon content, or on other goods in accordance with the emissions produced in production processes. Though several different definitions of carbon taxes have been formulated to date, for the purposes of this Guide we adopt the following guiding definition, based on the one used in the World Bank's *State and Trends of Carbon Pricing*.

> *"A carbon tax is a tax that explicitly states a price on greenhouse gas emissions or that uses a metric directly based on carbon (that is, price per tCO_2e)."*

While this definition is used as the guiding basis for the analysis in this Guide, it is also applied with some flexibility. Several jurisdictions have adopted taxes with the stated goal of furthering climate policy, even though the price is not directly linked to GHG emissions. A case in point is India's Clean Environment Cess, which places a tax on coal. For the purposes of this Guide, these taxes are also considered to be carbon taxes. At the same time, some jurisdictions have adopted carbon taxes that, while linking the level of the tax to the carbon content of fuels, do not precisely calculate the tax for each fuel based on its carbon content, as is the case for example in Mexico. All of these taxes should nonetheless be properly considered carbon taxes, and are so considered in this Guide.

2.2.2 A brief history of carbon taxes

Carbon taxes have been in place since the beginning of the 1990s. Predating even the United Nations Framework Convention on Climate Change (UNFCCC), they were one of the first policy tools to be employed with the specific objective of mitigating GHG emissions. Early carbon taxes were concentrated in the Nordic countries, with Finland adopting the first such tax in 1990, closely followed by Norway and Sweden in 1991, and Denmark in 1992. These early taxes were concentrated in the energy sector, and invariably "piggybacked" on existing excise taxes on fuels, using the same administrative system but linking the tax rate to the carbon content of the fuels.

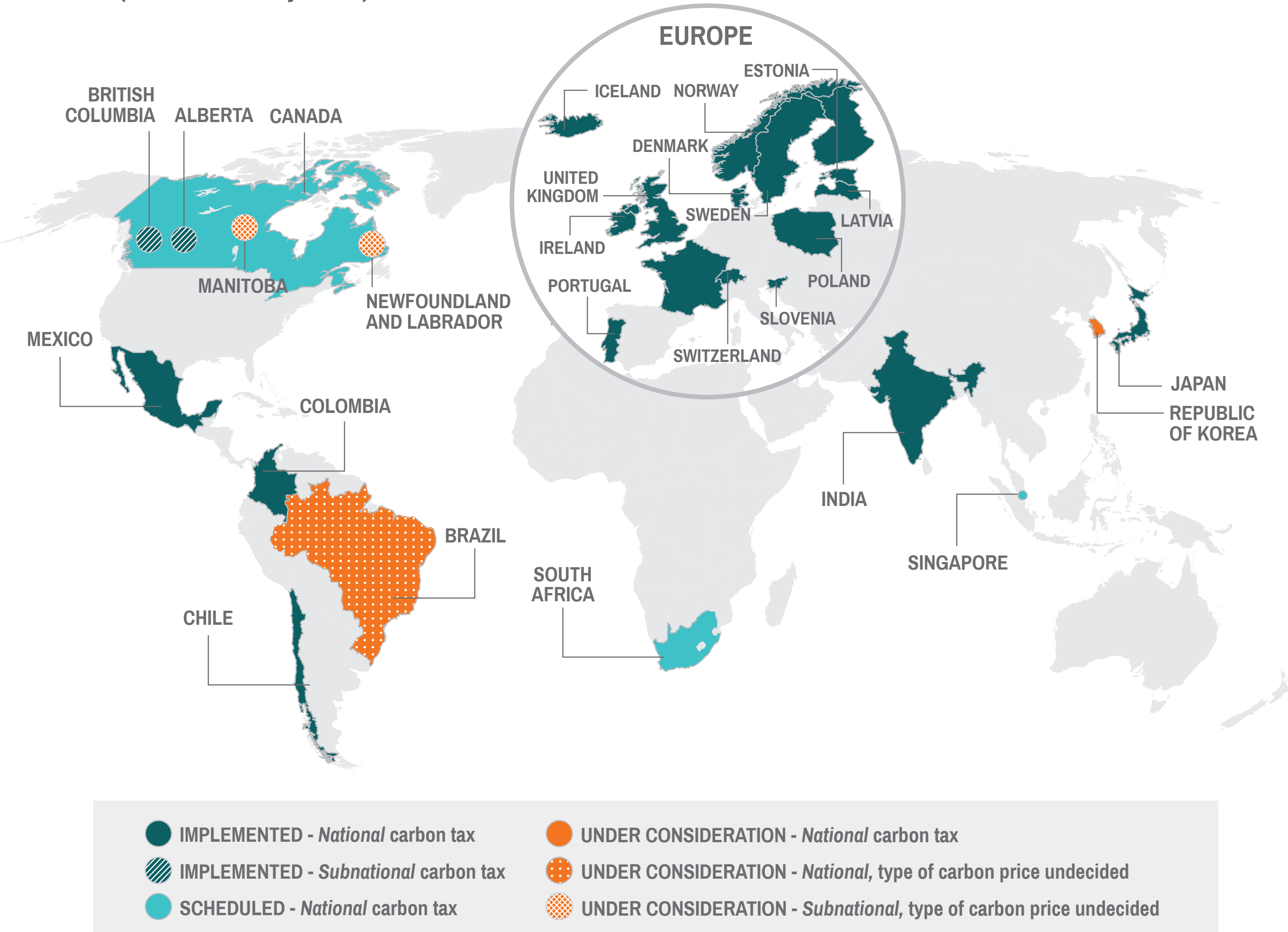
The Nordic carbon taxes adopted in the early 1990s continue to operate today, and have undergone multiple reforms in the interim, as countries have adapted their taxes based on experience and policy developments. Following this early wave of adoption, however, no new carbon taxes were adopted for over 15 years. Various proposals for a European Union-wide carbon tax tabled in the 1990s and 2000s failed to get the required unanimous support from Member States, eventually leading to the adoption of the European Union Emissions Trading System (EU ETS) as an alternative.[5] The adoption of the EU ETS, coupled with the growth of the "flexible mechanisms" created by the Kyoto Protocol, saw the attention of many countries focus on carbon market instruments, with carbon taxes getting less attention.

Since the late 2000s, however, there has been a renewed and growing interest in carbon taxes. Following the adoption of the Swiss carbon tax in 2008, a number of other European countries began to develop and adopt carbon taxes, together with other developed countries such as Australia and Japan. The early 2010s also saw, for the first time, carbon taxes being tabled in emerging economies, with South Africa, Mexico, and later Chile and

[4] The effective carbon rate is defined by OECD as the sum of specific energy taxes, carbon taxes, and ETS prices (OECD 2016).

[5] EU law requires that proposals on Union-wide taxation have unanimous support of Member States to become law. An ETS, by contrast, could be adopted by a "qualified majority" of Member States, easing its passage into legislation.

Figure 3. Carbon Taxes in Operation, Scheduled for Implementation, or under Consideration (as of February 2017)



India deciding to employ taxes to implement their climate policy goals. Figure 3 provides an overview of carbon taxes currently in operation or scheduled for implementation as of February 2017, while table 7 provides an overview of key milestones in carbon tax adoption.

The resurgence in interest in carbon taxes has come in the wake of enhanced global ambition to tackle climate change and the increasing realization that only concerted action by all countries can effectively address the problem. This trend culminated in the adoption of the Paris Agreement in December 2015, which entered into force in November 2016. In the context of the Paris Agreement, over 150 countries have already submitted (Intended) Nationally Determined Contributions (NDCs) to mitigate climate change. The resurgence has also developed alongside an overall increase in the share of tax revenue that is obtained from taxes on goods and services in recent decades, with many jurisdictions gradually reducing their reliance on income and corporate taxes, and using the tax system to achieve a range of policy goals beyond raising revenue (section 3.2).[6]

The growing experience with carbon taxes over the past years provides an abundant and increasingly diverse repository of experience on the development and implementation of carbon taxes. While many of the "second wave" of carbon taxes adopted in recent years have followed the original Nordic model of piggybacking on excise taxes, other jurisdictions have instead adopted broad-based taxes built around complex Measuring, Reporting and Verification (MRV) systems and included a range of novel features previously associated with ETSs, such as the use of offsets and benchmarking, the latter to reward early movers. Jurisdictions have similarly experimented with a range of approaches to revenue use, avoiding leakage and negative effects on vulnerable groups, and combining carbon taxes with ETSs. These experiences have shown carbon taxes are versatile instruments capable of adapting to a wide range of policy objectives and national contexts.

[6] PwC, 2013.

Table 7. Milestones in Adoption of Carbon Taxes

1990	Finland adopts first carbon tax Poland carbon tax
1991	Sweden carbon tax Norway carbon tax
1992	Denmark carbon tax
1995	Latvia carbon tax
1996	Slovenia carbon tax
2000	Estonia carbon tax
2008	Switzerland carbon tax British Columbia carbon tax
2010	Ireland carbon tax Iceland carbon tax India Clean Environment Cess
2012	Australia Carbon Pricing Mechanism
2013	United Kingdom Carbon Price Floor
2014	France carbon tax Mexico carbon tax Australia Carbon Pricing Mechanism repealed
2015	South Africa publishes Carbon Tax Bill Portugal carbon tax
2016	Canada announces national Carbon Price Floor
2017	Alberta carbon tax Chile carbon tax Colombia carbon tax Singapore carbon tax announced

2.3 CARBON TAXES AND POLICY INSTRUMENT OPTIONS

While carbon taxes can potentially support the achievement of a range of policy objectives, governments most commonly cite the aim of reducing GHG emissions as the chief driver behind their adoption. Carbon taxes can potentially be very effective in supporting mitigation targets, since they increase the costs of emitting, thereby providing an incentive to lower emissions in order to reduce tax obligations. Yet carbon taxes are just one of several tools that can support emission mitigation, and so before adopting a carbon tax it is important to understand how carbon taxes compare to the alternatives.

This section first provides a brief overview of the different instruments that governments can employ to tackle GHG emissions (section 2.3.1), before comparing the use of carbon taxes to the alternatives (2.3.2). Next it provides guidance on choosing the right instrument to fit different contexts and on using carbon taxes as part of a broader policy mix (section 2.3.3).

2.3.1 Understanding the full range of instruments

Different approaches exist to reduce GHG emissions—each with its strengths and weaknesses. As jurisdictions consider their options, determining which instruments are best suited to control carbon emissions will depend on three main factors:

- The sources of emissions in the jurisdiction;
- The main barriers to emission mitigation;
- National circumstances and policy objectives.

Chapter 5 discusses the application of a carbon tax to different emission sources, while chapter 3 discusses national circumstances and policy objectives in detail. This subsection considers the usefulness of a carbon tax to address different barriers to GHG mitigation, and then sets out some key differences between carbon taxes and other instruments in addressing these barriers.

2.3.1.1 Barriers to emission mitigation

The main barriers to emission mitigation can be grouped into three categories, different types of policy instruments being available to address each type of barrier (table 8).

- **Lack of incentives.** When no price is attached to GHG emissions, producers and consumers have little incentive to discover ways of reducing their carbon footprint. Even when mitigation technologies and practices are available and emitters are fully informed about their availability, they might not adopt the technologies and practices without an incentive or requirement to do so. To address this issue, governments can provide financial incentives for emission reductions, introduce regulations that limit emissions, and undertake direct government actions to lower net emissions (e.g., reducing emissions in state companies by enhancing energy efficiency).
- **Insufficient knowledge or technology.** Insufficient knowledge—at a societal level—on the sources of emissions, their impacts, and the technologies available to reduce them, can be a barrier to mitigation. Moreover, there could well be insufficient incentives for individual parties to incur the costs of generating the necessary knowledge and technologies because knowledge is a public good. To address this barrier, jurisdictions can encourage and support scientific study, research on carbon management practices, and technological development.

Table 8. GHG Emission Mitigation Issues and Policy Tools

PROBLEM	EXPLANATION	MARKET FAILURE	POTENTIAL INSTRUMENTS TO ADDRESS PROBLEM
Lack of incentives	Absence of incentives to change current (high-emissions) behavior. This may be due to the high costs of mitigation options and the fact that emitters are not responsible for the externalities caused by emissions.	Environmental externalities	Carbon tax; subsidies; command and control; emissions trading systems; government procurement;[a] and government provision[b]
Insufficient information or technology	Lack of understanding of the sources and causes of emissions, or absence of technologies to reduce emissions from these sources or strategies to address underlying causes.	Information creation / innovation as a public good	Research programs sponsored by government; research grants; patent protection; and X-prizes[c]
Insufficient information distribution	Although information exists, individual decision makers in the private and public sectors (consumers, producers, public administrators) do not have the information needed to make informed decisions.	Incomplete access to/ possession of information	Public information campaigns; labeling requirements; government capacity building; institutional support programs for technological best practice dissemination; and technology transfer schemes

Note: a. In this context, procurement takes on two distinct but related meanings. The first refers to the way in which a jurisdiction works through its supply chain to influence the production decisions of its supplier. For example, the jurisdiction might favor suppliers who can document that their products have a high recycle material content or have been produced with renewable energy. The second meaning of procurement refers to the jurisdiction's capacity to directly acquire environmental services from the private sector, for example, by contracting private service providers to afforest degraded lands to increase carbon stocks in newly established forest stands. In some settings this is referred to as payment for ecosystem services.

b. Government provision of services in this context refers to cases where the government operates through its own resources and personnel; the government's provision of parks and national defense are two common examples. In the context of GHG emission mitigation, governments may, for example, undertake forest carbon sequestration projects using government land, government resources, and government personnel, or invest government funds in renewable energy projects.

c. An X-prize is a public competition to encourage technological innovation. The sponsoring agency provides performance specifications for the required technology and stipulates a prize, generally a monetary amount. The first party to develop a design or perform a task that meets the specifications wins the prize. This is an outcome-oriented instrument because the participating parties are only evaluated on whether their submission complies with the required results.

- **Insufficient information distribution.** Another barrier to mitigation arises when consumers, producers, and public managers do not have the information they need to lower emissions. To address this hurdle, jurisdictions can, for example, undertake public education programs about the impacts of climate change, and provide technical assistance and information about available technological options to reduce emissions.

For each of these barriers to mitigation, different types of policy instruments are available to address that issue. These three problem categories are summarized in table 8. As discussed in section 2.3.4, a robust GHG emission mitigation policy will often include a mix of instruments designed to address all three of these barriers.

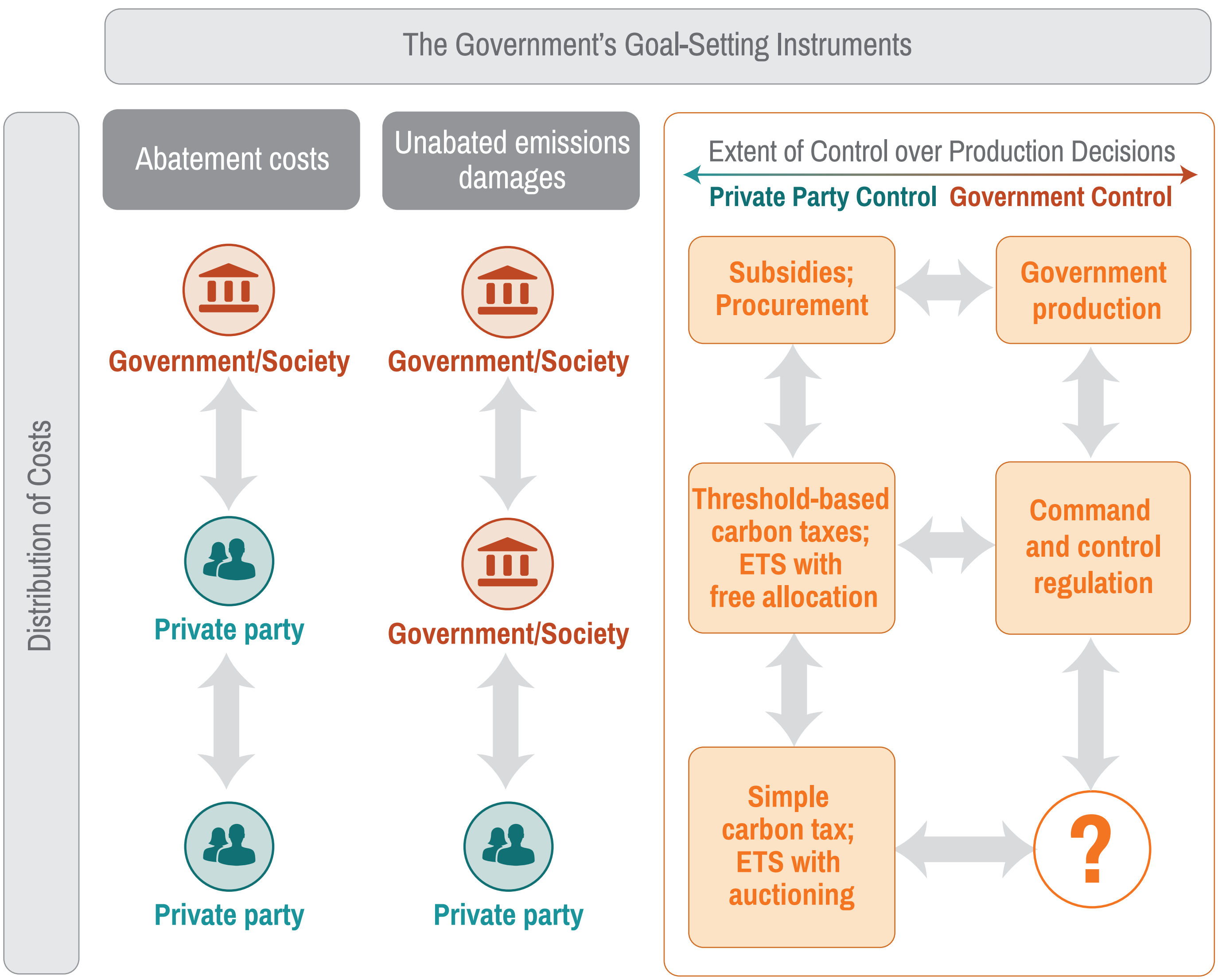
Carbon taxes fall in the first category of policy instruments—those designed to provide an incentive (or requirement) to reduce emissions. This is often conceived as requiring emitters to pay for the damages borne by the rest of society. These damages are often referred to as "externalities," because they accrue to parties that are not directly involved in—or are "external" to—the production and consumption decisions that lead to emissions of GHGs. By putting a price on carbon, governments price these externalities into emitting activities, providing an incentive for emitters to produce fewer emissions.

Characteristics of policy instruments to address externalities

Several policy instruments are available that can potentially address externalities. In determining if carbon taxes are the right instrument, it is useful to compare them with the alternatives such as command and control regulations, subsidies, ETSs and government provision of services. Three key factors distinguish the various instruments:

- The amount of discretion they afford covered entities;
- The way they distribute the costs of controlling emissions and the costs associated with unabated emissions; and

Figure 4. Environmental Policy Instruments Designed to Address Externalities



- The way the policy instrument helps to simultaneously advance other, nonenvironmental development objectives.

These differences are summarized below and illustrated in figure 4. It is worth noting that a thorough comparison will not only look at the characteristics of the policy instrument itself, but also at the political, economic, institutional, and social context in which they would be introduced.

Discretion afforded to private entities

The discretion afforded entities with regard to how emissions are mitigated can vary widely. Several broad approaches can be identified:

- **Wide private discretion.** Some instruments—such as subsidies, government production, taxes, and marketable allowances—are designed to allow private parties substantial discretion regarding the way the environmental goal is achieved. These instruments focus on outcomes—typically on emissions reduced or avoided. This may work by placing a cap on emissions (as in an ETS), incentivizing reductions (such as through reverse auctions for offsets)[7], or attaching a financial cost to emissions (carbon tax). What the programs have in common is that they are outcome-oriented and provide the private sector considerable freedom regarding how to achieve the desired outcome. Compliance with the law is assessed not by the steps that parties take, but by the results they achieve.

- **Limited private discretion.** At the other extreme there is relatively little private discretion—the government directs the processes for emission reductions through either regulations or direct provision. For example, using the regulatory approach, the government might limit which technologies can be used for industrial processes (for example, through Best Available Technology requirements), or which practices must be adopted in the design of new buildings. On the same side of the scale are actions taken directly by the government— where private discretion is, of course, non-existent. These may include measures to reduce deforestation and forest degradation in national parks or other government-owned land, or measures aimed at increasing energy efficiency in state-owned enterprises.

- **Partial discretion.** Many instruments—or variations in instrument design—give only partial control to private parties. For example, rather than specifying particular technologies, the jurisdictions can establish energy efficiency standards for appliances or carbon emissions rates for electricity generation. Private actors can determine themselves how to meet those standards. Similarly, jurisdictions can enter into contracts with private parties to develop abatement projects under arrangements of shared discretion. As depicted by the horizontal arrows in figure 4, a range of instruments exist between the extremes, which represent arrangements that provide partial or shared discretion for private parties.

Distribution of abatement and unabated emissions costs

The instruments used to address environmental externalities can also be differentiated by how they allocate the costs—who pays and for what? In this context, two types of costs are relevant. The obvious one is the cost of abatement, that is, the cost of reducing GHG emissions. However, policy programs seldom drive emissions to zero, so there are also the costs associated with the unabated emissions—the damages to society. The allocation of these two types of costs differs under the various policy instruments.

Starting in the middle of figure 4, command and control instruments, threshold-based carbon taxes, and ETSs with freely allocated emission allowances (where the available allowances are given away freely to covered entities) require the targeted parties to pay for emission abatement, but do not hold them responsible for the unabated emissions covered by the freely allocated allowances. By contrast, under subsidies and government procurement or production approaches, society (or its government) both pay for the abatement and bear the social cost of the unabated emissions. At the other end of the spectrum, under an arrangement such as a carbon tax,[8] parties pay not only for the reduction of their emissions but also for the emissions they fail to abate.[9] In these cases, the government may still shoulder the administration costs of the mechanism, which it may cover from carbon tax revenues.

An important implication of these distinctions is that the instruments at the bottom of the diagram generate government revenue while the ones at the top require governments to pay and therefore to identify additional sources of revenue. As such, the economic situation of the government and of the private party(ies) that the

[7] In a reverse auction, the government or other entity issues a call for bids to sell offsets. Project developers or other offset sellers then submit their bids, specifying the number of credits and the price they bid to sell each credit for, as well as documentation demonstrating that they comply with the eligibility criteria. The government will generally accept the lowest bids made. In a variation on this design, project developer bid to buy put options rather than to sell credits from a given project.

[8] Depicted in figure 4 as a "simple carbon tax," which can be differentiated from "threshold-based carbon taxes." Under the former, emitters pay for all of their emissions. Under the latter, emitters only pay tax on the portion of their emissions that exceed a specified threshold level or target baseline. The threshold or baseline can be individualized in the same way that different amounts of freely allocated emissions allowances are generally allocated to different emitters under an ETS.

[9] Note that the lower right-hand corner of figure 4 is unlabeled. The question mark refers to a hypothetical mechanism in which the government both dictates abatement technologies or practices and requires parties to pay in proportion to the unabated pollution. This is not a commonly used approach, and so there is no established term for this kind of mechanism.

government seeks to regulate will be key factors in determining the most suitable instrument.

A related implication is that instruments at the bottom of the diagram also more fully implement the "polluter pays" principle—which has gained important recognition both in international law and in many domestic legal systems. At one extreme, under subsidies, procurement, and government provision, polluters clearly are not paying, as governments pay for emission abatement and society bears the cost of the remaining pollution. At the other extreme, under an ETS with auctioning and simple carbon taxes, polluters pay for abatement and also pay a price for any remaining emissions, truly a polluter-pays outcome.

The allocation of costs is really a continuum of not only a wide variety of instrument types, but also of many different ways to design individual instruments, with different designs leading to different effects in terms of distribution of costs. For instance, both carbon taxes and ETSs can in principle impose the costs of damages from unabated emissions on society or the emitters. In ETSs, the government assumes the cost of unabated emissions when emission allowances are freely allocated, but the private party assumes this cost when they are auctioned. In the case of a carbon tax, the government may permit a specific amount of emissions free of tax (as is the case, for example, of South Africa).

2.3.2 Comparing the performance of carbon taxes with other instruments

To determine whether a carbon tax is the right policy instrument to address a jurisdiction's GHG mitigation goals, it is important for policy makers to consider, first, how it compares to the other instruments available at a general level and, second, whether the specific circumstances of the jurisdiction provide the right environment for a carbon tax to work effectively. This section considers these questions in turn.

2.3.2.1 Characteristics of carbon taxes

Carbon taxes are primarily designed to correct externalities and directly induce changes in emissions by putting a price on carbon. They will encourage emitters to invest in innovation and seek information about available cleaner technologies, but do not necessarily resolve the fundamental problems that cause underinvestment in research and imperfect information in decision making.

When compared to other instruments designed to address externalities, carbon taxes are distinguished by two factors:

- **High discretion.** Carbon taxes allow individual decision makers—consumers and producers—to decide how best to reduce emissions. Carbon tax liabilities are based on the actual level of emissions, and not on the means of achieving those emission outcomes. This permits emitters to adapt to their particular circumstances and preferences without being forced to consider a given limited range of solutions that applies to all parties. All other factors being equal, this will lead to more cost-effective abatement activities than when the government directs specific activities.
- **Costs paid by private party.** In their purest form, carbon taxes require that emitters not only pay for the cost of reducing emissions, but also for the unabated emissions. So, if a factory decides to reduce its carbon tax bill by cutting emissions in half, it has to pay for any new technologies or practices it needs to adopt to achieve that cut, and must also pay a tax on the remaining emissions. This means that carbon taxes, like an ETS with auctioning, can be a source of revenue for the government, and internalize the externalities created by GHG emissions.

The primary difference between a carbon tax and an ETS is that in the former case the government determines the price of emissions and relies on the emitting entities to decide how much carbon to emit (box 2), while in the ETS case the government decides the *amount* of emissions to permit, and allows firms, acting through the market, to decide what they will pay for the right to emit.

In carbon models, carbon taxes are often compared to other instruments with respect to their cost-effectiveness and efficacy.[10] Table 9 provides a summary of modeling studies that have compared policy instruments on one or both of these criteria. A few results emerge from these studies as well as the broader literature:

- Generally, instruments that generate a carbon price (carbon tax, ETS) as an incentive for carbon emission reductions are more cost-effective than standards or non-tradeable quotas.
- If there are pre-existing distortionary taxes, instruments that raise revenue are more cost-effective when the revenue is recycled (used to lower other taxes) than when it is refunded directly to the public (see chapter 8)
- Broader instruments–those that cover a broader range of carbon emissions rather than focus on specific sectors–are generally more cost-effective than narrow instruments, though this result can depend upon how revenue, if any, is used (see chapter 5 on targeting carbon taxes).
- Carbon taxes may or may not be more effective at reducing the level of emissions than other policy instruments, depending upon the level of the carbon tax (see RFF and NEPI 2010, Parry et al. 2014; chapter 6 on setting the carbon tax rate). Where regulations and taxes have similar implicit carbon prices, taxes generally offer much more cost-effective mitigation (see OECD 2016).

[10] The elasticity of demand is a measure of how responsive the amount of a good demanded is to changes in price. For highly elastic demand functions a small percent change in the price of a good will lead to a larger percent change in the amount demanded. For more on the elasticity of demand see chapter 4.

Box 2. Technical Note: Carbon Taxes vs. ETSs

Carbon taxes and ETSs appear in the same general region of figure 3, indicating that fundamentally they are more similar than different—both internalize the cost of GHG emissions by establishing a price on them.

As illustrated in figure 5, the primary difference between the two is that where taxes specify a price on emissions and allow the market to determine the quantity of emissions (left diagram), an ETS sets the quantity and allows the market to determine the price (right diagram). In theory, it is possible to achieve exactly the same outcome (in terms of emissions levels and abatement costs) with either instrument. Both instruments can also raise revenue for the government.

When the government is unsure of the marginal emissions benefit (MEB) curve, as is generally the case, which of the two approaches is chosen matters. Generally speaking, taxes provide certainty regarding the carbon price over a given period, often crucial for facilitating private investment in emission mitigation. An ETS can provide more certainty regarding the ability to meet a specific mitigation target but provides less certainty on the price. In practice, prices in carbon taxes tend to be significantly higher than in ETSs (World Bank, Ecofys and Vivid Economics, 2016).

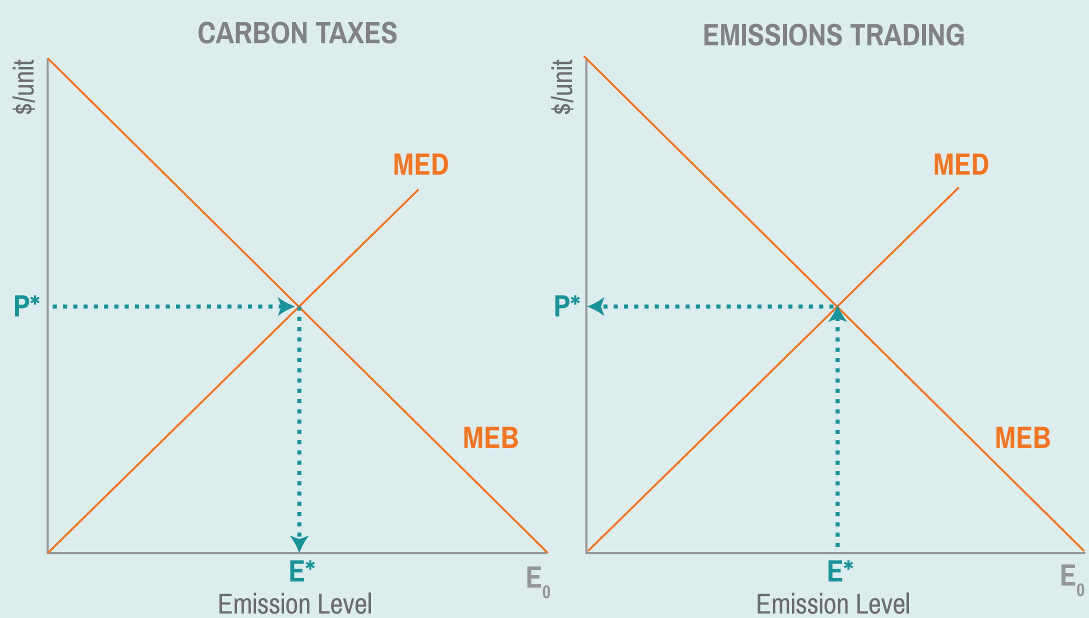
Emissions trading can bring economic efficiency gains by allowing participants to exploit the lowest-cost mitigation options across covered sectors. However, this presumes well-functioning markets with sufficient numbers of participants. In the presence of thin markets, ETS participants can incur substantial transactions costs, low liquidity challenges will limit efficiency gains, and individual firms can gain market power, thereby distorting the efficient use of emissions allowances.

Another challenge with ETSs is that other emission reduction policies can lead to lower market prices, dampening the price signal. Carbon taxes on the other hand are more likely to work in harmony with other emission reduction policies.

Where countries are interested in linking to the programs of other countries, this can most directly be achieved with ETSs, as linking can more easily equate the marginal costs of abatement across borders than can tax systems. It is however also possible to achieve agreements on price floors across carbon taxes, thus helping to equalize competition and ambition (section 7.4).

Finally, where an upstream carbon tax can often be piggybacked onto an existing tax administration, an ETS might require a new administrative structure to track and enforce allowance ownership, making carbon taxes often more suitable for jurisdictions that lack the substantial capacities needed to implement emissions trading.

Figure 5. Carbon Taxes vs. ETSs



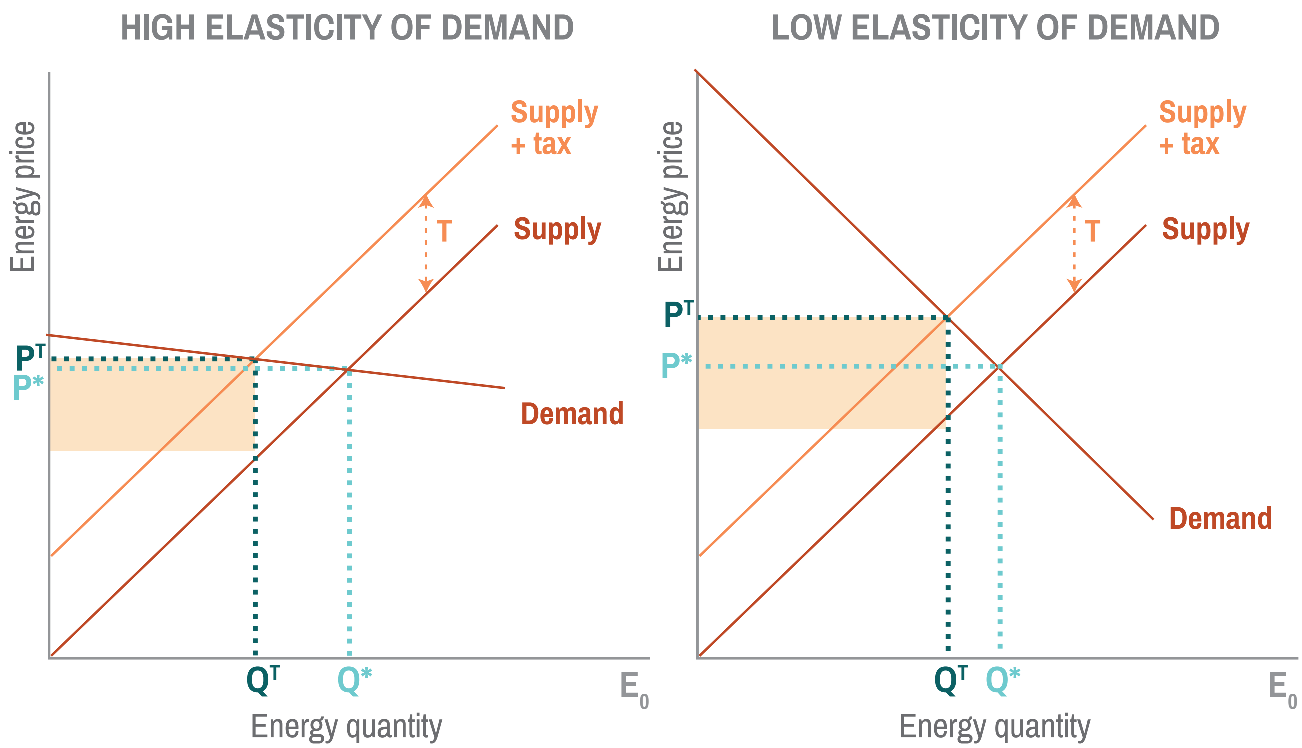
Note: P = Price; MED = Marginal Emissions Damage to the environment. MEB = Marginal Emissions Benefit (i.e., the economic value to polluters of being allowed to emit). The MEB is simply the mirror image of the Marginal Abatement Cost Curve (MACC).

Table 9. Example Studies Comparing Policy Instruments for Carbon Emission Reductions

AUTHORS	INSTRUMENTS COMPARED	METHODS	GEOGRAPHIC/ SECTOR SCOPE	EVALUATION CRITERIA	RESULTS
Tuladhar et al. 2014	Market-based and command and control	NEW ERA (integrated top-down/ bottom-up model	United States/ electricity and transportation	Cost-effective-ness (social cost)	Using command and control policy tools (e.g. renewable energy standards, renewable fuel standards, and national fuel economy standards) in place of or in combination with a carbon price mechanism (tax or ETS) increases the social cost by as much as 60 percent.
Rausch and Karplus 2014	Cap and trade and command and control	US REP (multi-regional CGE model)	United States/ electricity and transportation	Cost-effectiveness (social cost)	Using command and control policy tools (e.g. renewable energy standards, renewable fuel standards, and national fuel economy standards) in place of, or in combination with, combination with an ETS system increases the social cost.
Parry and Williams 2011	Market-based and command and control	Graphic and numerical analysis	United States/ economy-wide	Cost-effec-tiveness (social cost)	The net benefit of carbon tax approaches is much higher than emission standards when revenue from the former is recycled to reduce other distortionary effects. This result is larger when the instrument is applied economy-wide rather than to the electricity sector only. This result is reversed, however, if the revenue is not recycled.
Parry and Williams 1999	Carbon tax, energy tax, emissions allowances and command and control	CGE model	United States	Cost-effectiveness (social cost)	Generally, a broad carbon tax or BTU tax provides higher net benefits (after considering damages from GHGs) than even an idealized performance standard. Moreover, narrow quotas and narrow performance standards substantially reduce net benefits relative to either of the tax options. Freely allocated quotas perform similarly to the carbon tax if there are no distortionary taxes, but lose much of their advantage when tax distortions are present. The narrow gas tax was the weakest of all instruments under any conditions.
Liu et al. 2014	Carbon tax and command and control	Integrated top-down CGE and bottom-up model	China/iron and steel industry	Cost-effectiveness (social cost) and efficacy	Carbon tax controls multiple pollutants (CO_2, SO_2, NO_x) cost-effectively, but with limitations for the tax range examined (~USD 1-10/tCO_2e). The command and control instruments examined were more effective but costlier.

Note: BTU tax = a type of energy tax; CGE = Computable General Equilibrium; ETS = Emissions Trading System; U.S. REP = United States Regional Energy Policy.

Figure 6. Elasticity of Demand for Energy and Reductions in Energy Use



2.3.2.2 When is a carbon tax the right choice?

The specific national and sectoral contexts are highly relevant for the decision to either adopt a carbon tax or other GHG policy instrument. These factors can affect not only the design of the carbon tax (chapter 3), but also the initial decision to use a carbon tax or other policy instruments. Several considerations are particularly relevant when considering whether to adopt carbon taxes:

- **Taxes work best in market-driven economies.** Carbon taxes work through price signals. Emitters faced with higher prices for carbon emissions will be encouraged to decrease their GHG emissions, for example, by switching to lower emissions options, such as low-carbon fuel types or renewable energy use. Thus, the higher the reliance on markets and prices, the stronger will be this incentive. Where prices or producer budgets are to some extent determined by government and where technology choices are determined by regulation, the price signal might not be an effective tool for emission reduction.

- **To achieve GHG emission mitigation, taxes are best applied in elastic markets.** Governments that seek to reduce emissions through price signals should examine whether producers and consumers are likely to be responsive to price changes. Economies with high elasticities of demand for fossil fuels can, for example, expect to see substantial changes in consumption (and hence emissions), but where the elasticities of demand are low the response will be relatively small. As figure 6 illustrates, a given tax (T) on energy supply will induce a larger decrease in energy use (the difference between Q* and Q1) when the price elasticity of demand for energy is relatively high. In other words, to achieve the same reduction when elasticity is low (demand is inelastic) would require a higher tax. Therefore, if a jurisdiction seeks to substantially reduce emissions and has a relatively low elasticity of demand for energy, it will need to levy a relatively high tax. If there are political obstacles to such a high tax, alternative mechanisms may be preferable.

- **Taxes can provide benefits beyond GHG emission mitigation.** Even where elasticities are low and mitigation effects are relatively small, carbon taxes can bring other benefits. For example, they raise revenue while internalizing the social cost of emissions (the externalities described above). Indeed, where elasticities are low, more revenue is likely to be raised, as emission levels remain fairly constant. This revenue can be used to reduce other taxes or fund social and environmental programs. At the same time, this implements the polluter pays principle and could increase the efficiency of the tax system. These benefits are more fully described in section 3.2.

Ultimately, the suitability of a carbon tax for a particular jurisdiction depends not only on the nature of the carbon tax policy instrument, but on the political, cultural, and economic context in which it is implemented.

2.3.3 Carbon taxes as part of broader fiscal policy

When a carbon tax is adopted, it is built into an existing tax revenue system that includes many different instruments (such as income taxes, corporate taxes, fuel taxes, etc.). Within a single country, these instruments might include taxes levied at different levels, ranging from national to local levels, which reflect the economic and policy objectives of governments and authorities at different levels. When considering the adoption of a carbon tax, it is therefore important to understand the ways the tax could interact with other elements of the fiscal policy system.

2.3.3.1 Fitting carbon taxes within the existing tax system

Several factors regarding the characteristics of the overall tax system and the existing fiscal policy mix are particularly relevant in both determining whether to adopt a carbon tax and choosing the right design options:

- **Calculating the effective carbon rate.** A carbon tax will typically be one of several taxes levied on a product or the processes involved in creating or supplying it. Some of these taxes are closely related to carbon taxes. Energy taxes on fossil fuels in particular bear close resemblance, since the amount of tax in this case is directly related to the amount of energy used (if not the carbon content of the energy). They therefore combine with carbon pricing instruments to form what the OECD has termed the "effective carbon rate" (OECD 2016). In designing a carbon tax, it is useful for governments to consider not only the rate of the carbon tax itself, but also the overall effective carbon rate applied to energy (see chapter 6). The challenge of overlapping taxes can be exacerbated when there are multiple taxing levels within a jurisdiction. In cases where taxing powers for a given good or process are shared among different administration levels, it is crucial to ensure coordination between the different levels to get the appropriate effective carbon tax rate. Consolidating tax and regulatory instruments into a single tax may help ensure that the effective carbon tax rate is realized at the socially desirable level.

- **Shared vs. unique taxing powers.** In any situation where different levels of government tax a common economic base and the tax base reacts to the aggregate tax rate, a tax rate increase by one government level may impose a negative "fiscal externality" on the other level's tax revenues by causing a reduction in that taxable base. For example, if one government level (e.g., the federal government) taxes carbon while another level (e.g., a state) taxes fuel, a rise in the carbon tax will raise the price of fuel and subsequently reduce the quantity demanded. In this case, fuel tax revenues or sales tax revenues derived from those fuels will similarly decline. It is also possible that a single government level would, taken by itself, not approach the socially optimal rate, while as part of the aggregate (that is, all government levels combined) it would come much closer to it. Even when taxing powers are uniquely assigned to one level of government, they can still face political resistance from the other levels that independently tax the same base.

- **Determining the right level of government to adopt carbon tax.** Even where multiple levels of government have the legal power to adopt a carbon tax, there may be advantages and disadvantages to applying the carbon tax at different levels. For instance, centralized taxes may benefit from lower administration costs thanks to economies of scale, while more local taxes allow for possible gains from local knowledge about how best to administer the tax. Another important consideration is mobility: the more mobile the taxable activity, the more efficient it likely is to tax at a more centralized level. For example, a carbon tax might be capably implemented at the local level for coal extraction because of its limited mobility, which would also serve to reduce the number of points to monitor in the production process. By contrast, a carbon tax on motor fuels at the local level may encourage consumers to travel outside their jurisdiction to purchase fuel if lower taxes are paid nearby. In these cases, the tax may be better levied at the central level or be subject to a national floor price, as Canada has announced it would do in 2018.[11]

- **Integrating the carbon tax with existing taxes.** Building carbon taxes into existing tax instruments (sometimes referred to as "piggybacking") can offer administrative, legal, and political advantages. Many jurisdictions, such as Ireland, France, and Colombia, have integrated their carbon taxes with their existing fuel tax regime.

- **Structuring the carbon tax for simplicity and transparency.** A carbon tax that is expressed as a constant dollar amount per unit of carbon content in the taxed resource is the simplest form of taxing, while taxes levied on an ad valorem basis (i.e., based on the value of the transaction) can be far more complex, given that retail and wholesale prices often fluctuate substantially. Moreover, jurisdictions can use the simplicity of the carbon tax to help citizens understand the implications of the tax for their tax burden. For example, British Columbia has been careful to point out that it does not collect more taxes when the price of fuels changes.

2.3.3.2 Legal, political, and institutional issues

In addition to these overall design considerations, a number of institutional and legal factors are relevant for governments to consider when adopting a carbon tax:

[11] See, for instance, https://www.carbontax.org/where-carbon-is-taxed/british-columbia/.

- **Whether it is called a tax can matter.** Economically speaking, there is no distinction between a tax, a regulatory fee, or a penalty on carbon production. Yet the language used can matter in the political acceptance of the policy, the ability of a particular level of government to adopt the instrument, and the legal rights of the stakeholders involved. For example, a given level of government seeking to expand its fiscal space will sometimes maneuver the framing of a revenue instrument as a "charge" or "penalty," when it does not have the authority to levy a "tax," and so each country is likely to have its own legal requirements for determining how taxes, charges, fees, and penalties are defined, used, and constrained.

- **What kind of tax it is can matter.** Even when the financial instrument clearly is a tax, what type of tax it is can play a role in the assignment of taxing powers. One of the most frequent tax typologies distinguishes between "direct" and "indirect" in taxes. The difference between the two is whether the tax is levied directly on persons or indirectly, through firms. Even if a tax is passed down the supply chain and ultimately paid by customers through higher prices, a tax may still be considered indirect as long as it is collected and remitted by firms. The taxonomy does matter for the tax design and sometimes affects the procedure for its adoption. For example, in the United States, a direct tax levied by the federal government must have an equal per capita tax burden across all states, a legal requirement that has actually prevented the national government from using direct taxes for most of the country's history. Canada has the inverse approach to the definitions, indirect taxes being the solely prerogative of the federal government. In Switzerland, the constitution requires that there be established principles for aligning direct taxes across the municipalities and cantons, as well as the confederation.

- **International trade agreements can affect a carbon tax.** International trade agreements can be relevant to the specifics in defining the context for a carbon tax. In particular, the General Agreement on Tariffs and Trade (GATT) and other rules of the World Trade Organization (WTO) restrict the ability of countries to structure a tax in a way that discriminates in favor of domestic producers or specific importers. Parties to WTO agreements can apply indirect taxes to imports as long as the tax is not directly connected to the act of importation. That is, the tax can be extended to imports, provided an adjustment is made to ensure the amount of the tax levied on imports does not exceed the amount of carbon tax levied on similar products manufactured domestically, and the domestic country has products being taxed that are similar to those imports (section 7.4.).

2.3.4 Carbon taxes as part of the climate and energy policy mix

Carbon taxes are often part of a larger climate and energy policy mix that could include measures such as government-funded research, industrial energy efficiency standards, vehicle fuel efficiency standards, and technology standards for electricity generation. A government may adopt a mix of policy instruments for different reasons, some motivated by good policy, some precipitated by circumstances, and some by sheer political necessity.

It is important to understand how these instruments can complement, overlap with, and even counteract each other. Although in practice it is sometimes difficult to isolate these effects, the distinction can nevertheless be useful.

Complementary policy instruments are those that work together to produce desired outcomes. Generally, complementary instruments are most useful when either multiple types of market failures or multiple social goals exist. Jurisdictions may sometimes need to engage in "gap-filling" because existing systems are incomplete. In this context, the following points should be borne in mind:

- **Multiple market failures.** Good practice suggests that when multiple market failures exist—for example, public good benefits of research, imperfect information, and externalities—a robust instrument mix is definitely justified. Moreover, where multiple market failures exist, governments may adopt separate instruments to address each of these, for example, by adding research and development programs and public information programs, which address different market failures than a carbon tax. In the case of GHG emissions, a jurisdiction may (i) provide research grants to encourage innovation in energy efficiency, (ii) implement a public information program to educate parties about the range of cleaner technologies available, and (iii) adopt a carbon tax to provide incentives to adopt those technologies.

- **Preexisting and incomplete policy instruments.** In many cases, governments add carbon taxes to a set of provisions that are already in place. Often, the carbon tax is intended to fill gaps in existing systems. For example, several EU countries, already subject to the European Union Emissions Trading System (EU ETS), have started levying carbon taxes on sources that are not covered by the existing system. Governments often use complementary instruments where it is not practical to apply a carbon tax. For example, if a carbon tax program is limited to fossil fuels (as is the case in most existing systems), the government might adopt additional instruments to address emissions from agriculture and industrial processes.

- **Multiple social goals.**[12] Similarly, where there are related but distinct environmental goals—for instance, reducing both GHG emissions and local air pollutants—the government will generally need multiple policy

[12] In a sense, the distinction between multiple market failures and multiple objectives is artificial. Where multiple market failures exist, governments have objectives to address each one. The distinction is still useful to remind us that multiple objectives emerge in different ways

instruments. Furthermore, when the carbon tax exacerbates another problem, it may be necessary to adopt complementary policy tools. For example, a government concerned about the impact of carbon taxes on low-income households may consider adopting measures to mitigate these impacts (chapter 7).

In some cases, the additional policy instruments will interact with the carbon tax. For example, a congestion fee to reduce urban traffic could also reduce the amount of carbon dioxide emissions from transportation. Similarly, regulation of PM2.5[13] from electricity generation might reinforce a carbon tax by reducing total energy use.[14]

Overlapping policy instruments are those that share objectives but may be redundant. For example, to reduce carbon emissions, using both carbon taxes and a renewable energy portfolio standard (RPS), both covering electric utilities, would be an overlapping mix of instruments. The challenge with overlapping instruments is that each can interfere with the operation of the other. In the case of a carbon tax and RPS, for example, if the policy goal is only to reduce emissions, then the constraints that the RPS places on technology choice could interfere with the utilities' ability of finding the lowest-cost abatement options and thus indirectly raises the total costs of mitigation. Of course, these policies do not invalidate the case for the carbon tax entirely as it offers more than just incentives for lowest-cost abatement, but such policies might dim its effectiveness.

Counteracting policy instruments are those that work in opposition to each other. For example, carbon taxes and vehicle fuel consumption subsidies would be countervailing policy instruments—one reduces emissions by raising the effective price of fossil fuels while the other increases emissions by lowering their price. Jurisdictions should generally seek to minimize the use of countervailing policy instruments.

[13] PM2.5, fine particulate pollution, refers to matter that is 2.5 micrometers or less in diameter. It is composed of smoke and soot, dust and dirt, and secondary derivatives of those materials. PM2.5 is linked to a number of health problems, most notably respiratory ailments.

[14] Estimates from Parry et. al. (2014: 24) suggest a significant carbon tax, an average of US$57.5/t$CO_2$e among the top 20 emitting countries.

Key Considerations

- Carbon taxes are designed to address the externalities associated with GHG emissions and provide a financial incentive for emission mitigation, making them a good climate policy choice where governments seek to correct the absence of incentives and internalize pollution costs.
- In their purest form, carbon taxes require emitters to pay for reducing emissions and for the emissions they fail to avoid. This approach reflects the "polluter pays" principle, while also generating government revenue.
- Carbon taxes can be designed to generate a number of benefits beyond GHG emission mitigation and government revenue, including local environmental benefits and higher efficiency of the tax system.
- In comparing carbon taxes and ETSs, it is important to consider the relative importance of providing certainty on the carbon price on the one hand—important for investment decisions—and reaching a specific mitigation target for covered sectors on the other hand. It is also important to consider whether market conditions are suited to an ETS, and the different administrative costs associated with each instrument.
- Carbon taxes are generally implemented as part of a larger tax system. It is thus important to consider how the carbon tax would fit within the existing legal and administrative system. It is equally important to consider how a carbon tax would complement (or conflict) with other climate and energy policy instruments.

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3 PREPARING FOR CARBON TAX ADOPTION

At a Glance

When considering the adoption of a carbon tax and specific design options, it is important to examine the available options and consider them in light of the relevant context. Experience shows that the right design options depend closely on the policy goals and national circumstances of each jurisdiction. Developing a clear picture of these factors at the outset is therefore crucial to enabling policy makers to make informed choices when designing the different elements of the carbon tax.

The following policy objectives are particularly important for informing carbon tax design:

- **Mitigate GHG emissions.** Define the overall greenhouse gas (GHG) mitigation trajectory the jurisdiction has set and the role of the carbon tax in achieving it;
- **Raise revenue.** Clearly define how the revenue will be used—whether for the general budget or for specific policies—and the amount of money that is sought;
- **Promote low-carbon development and local environmental goals.** Identify economic objectives for developing low-carbon sectors and for reducing local pollution;
- **Improve the efficiency and effectiveness of the tax system.** Shifting taxation from “goods” to “bads” and reduce tax evasion and avoidance.

In all cases it is important to consider the interactions between these objectives. While some objectives will align, others may lead to conflicting design choices. A certain degree of prioritization is thus inevitable.

Alongside policy objectives, it is important to consider the national circumstances that influence design choices, in particular:

- **Government capacity and rule of law.** The way the carbon tax is designed will affect the capacities that are needed to effectively implement the tax. Upstream taxes often require minimal administration capacities, while downstream taxes may require significant competences. Good governance will also be important for ensuring effective implementation.
- **Emissions profile and economic context.** Understanding the current and projected future emissions profile of the jurisdiction in question is crucial for identifying where to place the tax. Jurisdictions can also benefit from understanding the dynamics and economic structure of key sectors.
- **Political environment.** Jurisdictions where addressing climate change is a high priority for politicians and the public will often have more flexibility in the design of the carbon tax and may find it easier to adopt a broad scope or higher rates. Jurisdictions where taxes of any kind are especially unpopular may consider using the tax revenue to lower other taxes

When considering design choices based on policy objectives and national context, policy makers can make use of a set of principles to help evaluate and inform different options. While the choice of principles will vary for each jurisdiction, a useful starting point is provided by the FASTER Principles for Successful Carbon Pricing. Each of these principles can be applied to a range of carbon tax design choices, and are considered throughout this Guide.

The FASTER principles are the following:

Fairness	Transparency
Alignment of policies and objectives	Efficiency and cost-effectiveness
Stability and predictability	Reliability and environmental integrity

3.1 INTRODUCTION

Before a government proposes the adoption of a carbon tax, it is important to engage in a process through which it closely examines all available options and considers them in light of the relevant context. Engaging in this process early can ensure the tax is well designed and responds to both policy objectives and national circumstances, thereby enhancing the political acceptability of the tax and reducing the likelihood that substantial overhauls will be needed in the short or medium term.

This chapter covers three central questions that should be addressed at the outset of carbon tax design:

1. What are the main **policy objectives** that the tax seeks to achieve?
2. What are the **national circumstances** that are likely to influence the adoption and implementation of the carbon tax?
3. What **principles** should guide the design and implementation of the carbon tax?

These questions are closely related and, when designing a carbon tax, they should be considered together. For instance, the principles of carbon tax design will reinforce policy objectives, while policy objectives (for example, a GHG mitigation target or support for a certain sector) will be influenced by national circumstances.

From a procedural point of view, it is important to put in place mechanisms at the outset that support effective design. Establishing interministerial committees, for instance, can help ensure that policy objectives are aligned across different sectors (e.g., climate, energy, finance). Aside from generally enhancing policy coherence, this also increases the likelihood that the carbon tax will be effective and gain broader political acceptance. Interinstitutional coordination is further discussed in section 9.2.

It is also important to develop mechanisms early on for engaging nongovernmental stakeholders such as the private sector, civil society, and the general public. This issue is touched upon in section 3.3.3, and is more fully addressed in other PMR technical notes.[15]

This chapter is structured as follows. Section 3.2 focuses on policy objectives that are relevant to tax design, and identifies the main decisions these objectives affect. Section 3.3 looks at national circumstances under the same light. Finally, section 3.4 lays down the principles that can be used for guiding the choice of design options.

[15] PMR & ICAP, 2016; Singh & Bacher, 2015.

3.2 DETERMINING POLICY OBJECTIVES

Carbon taxes have the potential to achieve a range of different policy objectives, and the relative importance a government places on these objectives is a crucial factor informing policy makers' design choices. An essential first step in carbon tax design is therefore to clearly define the objectives the government seeks to achieve through the tax.

While most governments considering the adoption of a carbon tax will have a fairly clear idea of high-level objectives such as "reducing GHG emissions" or "raising revenue," for maximum effectiveness of the carbon tax, the definition of these objectives should go further and consider the specific targets pursued within these general objectives as well as their relative importance. This section therefore first discusses four headline objectives that drive carbon tax adoption—GHG emission mitigation, revenue raising, low-carbon development benefits, and increased efficiency of the tax system—and the specific objectives to be determined in each case. Second, it presents practical considerations for weighing the relative importance of the different objectives pursued. The implications of different policy objectives for the design of specific elements of a carbon tax are discussed more at length in the subsequent chapters.

3.2.1 Defining specific objectives

This section discusses the four most commonly cited policy objectives for adopting carbon taxes: GHG emission mitigation, raising revenue, contributing to low-carbon development and other environmental protection aims, and increasing the efficiency of the tax system.

3.2.1.1 GHG emission mitigation

Limiting GHG emissions is consistently cited by policy makers as one of the principal objectives underlying carbon tax adoption.[16] With more and more countries and subnational jurisdictions adopting quantifiable mitigation targets—whether as absolute targets or as a range of relative and intensity-based targets[17]—carbon taxes are becoming an increasingly prominent policy tool to achieve them. The more specific a GHG emissions objective pursued is, the more effective the carbon tax designed to support it will be.

[16] In a survey conducted for this study of seven jurisdictions designing, implementing, or considering a carbon tax, GHG emission mitigation was cited by all respondents as a "very important" objective of the carbon tax, and in all cases as the single or joint most important reason for adopting the tax.
[17] See UNFCCC INDC Portal: http://www4.unfccc.int/submissions/indc/Submission%20Pages/submissions.aspx.

Figure 7a: Steadily Declining Emissions

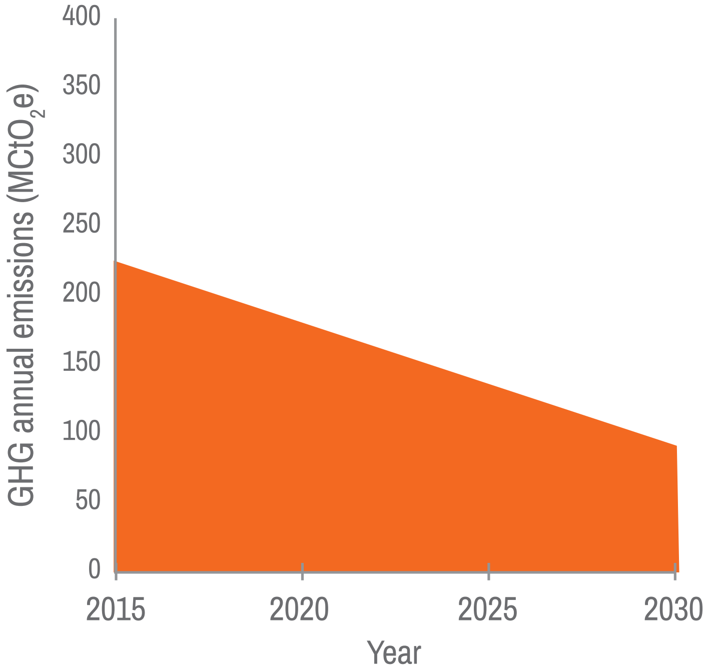
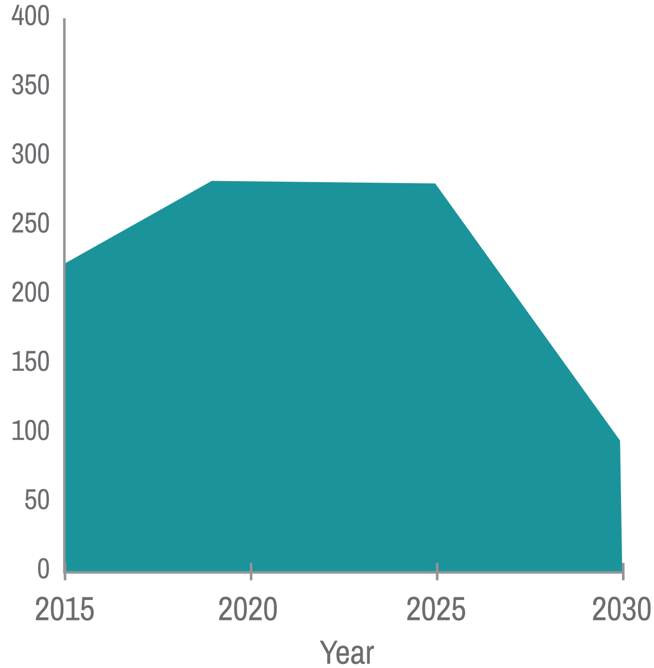


Figure 7b: Emissions Peak, Plateau, Decline



The first and most obvious specific objective a jurisdiction must determine is the emissions target it seeks to achieve and over what time frame it is pursued. Most jurisdictions have already defined such targets as part of their Nationally Determined Contributions (NDCs), as well as through national or subnational climate policies and strategies. In some cases, targets apply to the whole economy, while in others they apply only to specific sectors. Some jurisdictions have both economy-wide and sectoral targets.

A second feature to determine is the emissions trajectory the jurisdiction seeks to achieve over time or, in other words, the rate at which it wishes emissions to decline, or the date by which emissions should peak, plateau, and subsequently decline. Figures 7a and 7b illustrate two potential emission reduction trajectories in jurisdictions with the same absolute emission reduction target.

Box 3. Implications of GHG Mitigation Objectives for Carbon Tax Design

ISSUE	IMPLICATIONS	SEE FURTHER
Tax base	Understanding the role different sectors are expected to play in achieving mitigation targets and the different (present and future) policies that apply to those sectors can help determine what to focus the carbon tax on.	Chapter 5
Tax rate	The overall emission reduction target (economy-wide or sectoral) will influence the tax rate, while the desired trajectory will influence the change in the rate over time. The level of existing or planned energy taxes will also influence these decisions.	Chapter 6
Use of revenues	Emission reduction targets and the chosen policy mix can influence the decision on how to use tax revenues. Where there is a policy or funding gap for reducing emissions in uncovered sectors, for instance, earmarking revenue for these industries can be an option, as well as providing targeted tax reliefs. Permitting the use of domestic offsets from those sectors can serve a similar purpose.	Chapter 8

While in country A, emissions are reduced gradually from the base year (2015) to the target year (2030), in country B emissions rise slightly, before peaking, plateauing, and then declining to the target. Naturally, in country B, the decline happens much faster once it sets in because it needs to compensate for the country's growth since 2015 to be able to meet the same target. In addition, its total emissions over the period 2015–30 are substantially higher than in country A. Since the intended trajectory affects how much emission reduction a jurisdiction seeks to achieve over a period of time, it influences the temporal dimension of carbon tax design. For instance, a jurisdiction may expand the tax to more sectors or increase the tax rate over time to achieve a certain emissions trajectory.

In jurisdictions with targets relative to a baseline (typically a business as usual, or "BAU" projection) or intensity-based targets (e.g., reductions per unit of GDP), similar considerations apply. A jurisdiction with a target relative to BAU must decide the trajectory through which emissions will deviate below the BAU scenario, for instance, through a steady gradual reduction relative to the BAU or by continuing to stay close to the BAU scenario for a certain period and then reducing at a faster rate. An intensity-based target can similarly be met through gradual reductions in emission intensity or through a less regular trajectory.

Alongside defining the emission reduction target and trajectory, it is important for policy makers to consider the role or contribution of the carbon tax in achieving the target. As discussed in section 2.3, carbon taxes can be used as a complement to a range of policies—whether explicitly climate-driven or otherwise—to achieve mitigation objectives. The better a jurisdiction can define what policy mix it will use to achieve its objectives and what contribution it wants the carbon tax to make toward achieving mitigation targets, the better positioned it will be to define the carbon tax in a way that reflects the intended contribution. For instance, by calculating the "effective carbon price" set by energy taxes, carbon taxes, and emissions trading systems (ETSs) for a given product (section 2.1), jurisdictions can understand the interactions of these different instruments in creating a price signal for emission reductions in a given sector. This in turn can help determine the appropriate tax rate.

3.2.1.2 Raising government revenue

Alongside mitigating GHG emissions, raising revenue is a commonly cited reason for introducing carbon taxes.[18] Revenue raising should be understood broadly not only where jurisdictions seek to raise additional revenue through the carbon tax—whether for general government spending or for specific purposes—but also where they seek to use it as a substitute for other sources of revenue. Several jurisdictions place high importance on "revenue-neutral" carbon taxes since they allow them to reduce taxes in other areas, for example labor or corporate taxes.

Within the broad objective of raising revenue, two questions stand out:

1. How will the revenue be used?
2. How much revenue is sought for each specific area of funding?

[18] In the survey conducted for this study, four out of seven jurisdictions indicated that raising revenue for government spending was an important or very important consideration in adopting the carbon tax and one indicated it was a "relevant' consideration." By contrast, one of the seven jurisdictions indicated that the ability to reduce other taxes was an important consideration in adopting the tax, while three jurisdictions indicated this was a "relevant consideration."

Box 4. Implications of Revenue Objectives for Carbon Tax Design

ISSUE	IMPLICATIONS	SEE FURTHER
Tax base	The level of revenue-raising ambition can affect the breadth of sectoral coverage, that is, the tax base. Where significant revenue is sought, governments may choose to include more sectors, or those with the highest level of emissions and/or highest ability to pay.	Chapter 5
Tax rate	The level of revenue-raising ambition can also affect tax rates, with different rates having different effects on the amount of revenue raised within a given sectoral scope.	Chapter 6
Use of revenues	The key issue affected by revenue-raising objectives is how the revenue is to be used.	Chapter 8

Box 5. Implications of Objectives Relating to Low-Carbon Development and Local Environmental Benefits for Carbon Tax Design

ISSUE	IMPLICATIONS	SEE FURTHER
Tax base	Where governments have local environmental objectives such as reducing air pollution, they may seek to target the sectors and gases primarily responsible for the pollution. Sectoral development objectives may also influence the choice of tax base. For example, applying a carbon tax to electricity generation can help foster renewable energy investments and incentivize modernizing the electricity distribution system, while a tax on heavy industry can incentivize modernization and energy efficiency in those industries. In net energy-importing countries, taxes on fossil fuels can improve the country's balance of trade.	Chapter 5
Tax rate	Where development or local environmental objectives are relevant, governments may set the tax rate at the level of incentive projected to be needed to achieve these. For instance, the level of competitive advantage currently enjoyed by a polluting industry may influence the tax rate necessary to level the playing field vis-à-vis cleaner industries.	Chapter 6
Use of revenues	Where governments wish to stimulate investment in specific low-carbon industries, they may consider providing exemptions/rebates to those sectors or permitting the use of offsets from those industries. These incentives could also be given to entities that reduce their GHG emissions or achieve other environmental objectives.	Chapter 7 and 8

These questions will generally need to be considered in light of broader policy objectives, often beyond climate change policy. For instance:

- Jurisdictions under overall fiscal stress may seek to raise revenue for the overall budget or to pay off their national debt as, for example, Ireland did.
- Jurisdictions planning major social or economic reforms (e.g., education or health care reform) may seek to raise revenue to fund these plans, as is the case of Chile.
- Jurisdictions may also promote employment by using revenue to reduce labor taxes as, for example, France did.

In each case it is important to have a clear idea of the contribution carbon tax revenue is expected to make toward reaching these objectives, and in turn the level of revenues targeted through the carbon tax.

3.2.1.3 Achieving low-carbon development and local environmental benefits

Besides the central objectives of GHG mitigation and raising revenue, several jurisdictions cite a range of aims relating to low-carbon development[19] or environmental protection[20] beyond GHG mitigation as ancillary objectives behind the introduction of a carbon tax. In many developing countries, incentivizing the development of new or nascent economic sectors or addressing local environmental issues are often more immediate and pressing political objectives than GHG mitigation. Carbon taxes can provide a financial incentive for consumers and businesses to adopt cleaner technologies, purchase greener products, or switch to less polluting fuels. This in turn can help to address a range of government objectives, for example, modernizing the energy system, limiting the growth in energy demand, supporting the development of public transport systems, or supporting growth and employment in green industries.

Carbon taxes can support these and other policy objectives in two major ways. First, they can provide an incentive for shifts in behavior or investment that support policy

[19] All of the jurisdictions surveyed indicated that "encouraging the development and deployment of low-carbon technologies" was an important consideration in adopting their carbon tax.
[20] Five of the seven jurisdictions surveyed characterized this as either a "relevant" or "important" consideration in adopting a carbon tax.

Box 6. Implications of Objectives Relating to Tax System Efficiency for Carbon Tax Design

ISSUE	IMPLICATIONS	SEE FURTHER
Tax base	Where jurisdictions seek to reduce the deadweight loss of taxation, they may look to tax products or activities that are currently not taxed or taxed at low rates. Where they seek to increase the tax base by expanding the number of taxes paid by the informal sector, they may place the tax upstream and target the fuels most used in the informal sector.	Chapter 5
Tax rate	Where governments aim for revenue neutrality, it is important to consider the level of revenue expected to be raised at different tax rates and how this relates to the revenue forgone from reducing other taxes.	Chapter 6
Use of revenues	Jurisdictions aiming to improve the efficiency of their tax system will generally want to use at least part of the revenue to reduce other taxes.	Chapter 8

objectives. Second, they can raise revenue that can be used to fund programs or incentives that further support those aims. Moreover, these two effects can be mutually reinforcing—the incentive provided by the tax combined with the incentives funded by tax revenue providing a double "carrot-and-stick" incentive that supports the government's policy.

3.2.1.4 Improving the efficiency and effectiveness of the tax system

For some jurisdictions, improving the efficiency of the taxation system by shifting taxation from "goods," such as labor and capital, to "bads," such as GHG emissions, is an important motivation for adopting a carbon tax.[21] Such "revenue-neutral" carbon taxes[22] may improve the efficiency and effectiveness of the taxation system in different ways. For example, they can reduce the deadweight loss of taxation by reducing the tax rate on tax bases that are often already highly taxed (e.g., labor and capital) and shifting it to a product that is not currently taxed (GHG emissions).[23] In jurisdictions with large informal sectors, reducing labor or corporate taxes while increasing upstream taxes on fuel can increase the effective tax base, since the tax will be incorporated into the purchase price of fuel, and therefore be paid by both formal and informal businesses. On the other hand, only formal businesses pay corporate and income taxes. Upstream carbon taxes can also reduce tax administration costs, and are often associated with reduced tax evasion rates compared to other forms of taxes.[24]

3.2.2 Prioritizing and aligning objectives

Most jurisdictions adopting or considering carbon taxes have multiple overall objectives, which will often each consist of a range of specific targets. While in some cases these objectives are naturally compatible, sometimes a more proactive effort will be needed to ensure compatibility. In other cases, objectives may conflict, and political decisions will have to be made to prioritize the most important objectives. Table 10 provides a simple illustration of this, while subsequent chapters will discuss the different decisions that need to be made in the context of different design options.

Prioritizing and aligning objectives will often come down to political decisions, frequently in the context of negotiation between different political parties and consultation with key stakeholders. Yet a number of practical tools exist to support

[21] Four out of the seven jurisdictions surveyed indicated that eliminating other taxes was either a "relevant" or "important" consideration in adopting the carbon tax, and several other jurisdictions that participated in interviews for this study also emphasized this aspect. Two jurisdictions also cited "improving economic efficiency of the tax system" as one of the considerations determining their use of revenue.

[22] See further section 8.2.

[23] See section 8.2.

[24] In the United Kingdom, for example, the total "tax gap" (defined as the difference between the amount of tax that should, in theory, be collected by HMRC, and what is actually collected) is less than 1 percent for excise taxes on petroleum products, compared to 10.3 percent for VAT, 7.6 percent for corporate tax, and 5.2 percent for income tax, National Insurance contributions, and capital gains tax (HM Revenue and Customs, 2016).

Table 10. Examples of Potential Synergies and Conflicts between Objectives

ISSUE	POTENTIALLY ALIGNING OBJECTIVES	POTENTIALLY CONFLICTING OBJECTIVES	SEE FURTHER
TAX BASE	Ambitious goals on GHG mitigation and revenue raising may both point toward broad coverage. Similarly, where governments seek to raise significant amounts of revenue in the short term and achieve short-term emission reductions across the economy, they may seek to apply the tax to all sectors within a relatively short period of time.	In sectors with highly elastic demand for taxed products (e.g., fuel), the price signal is likely to be very effective, leading to significant emission reductions. In the long run, however, this will entail lower revenues, since reduced emissions will result in less tax being collected. Where the carbon tax only covers a limited number of sectors, the objectives of emission mitigation and long-term revenue raising may therefore point to different decisions on which sectors to cover.	Chapter 5
TAX RATE	Ambitious GHG mitigation targets and growth plans for low-carbon energy may both point toward high tax rates for high-carbon energy industries, and where the government has short- to medium-term targets in these areas, they may consider introducing a high rate right away or quickly moving to one.	Where a jurisdiction has long-term revenue needs and pursues a medium-term emissions target, it will need to choose between adopting a high tax rate straight away and thereby encourage short- and medium-term emission reductions, or gradually raising the rate, in that way only encouraging emission reductions in the long run.	Chapter 6

the decision-making process. Carbon tax modelling, in particular, can help policy makers assess the likely (overall and sector-specific) impacts of different design options on factors such as GHG mitigation, economic performance, revenue generation, and local environmental protection. It can support decision makers in choosing the design options that will contribute the most to their collective policy objectives, or at least put the different objectives in context. Approaches to carbon tax modeling are discussed in chapter 4.

3.3 FRAMING THE NATIONAL CONTEXT

Having defined the policy objectives sought by the carbon tax, it is important for policy makers to have a clear picture of the relevant national context. These circumstances affect a wide range of decisions, from whether to adopt a carbon tax, to determining the tax design options that are best suited to the jurisdiction.

This section therefore identifies the major economic, social, legal, and political circumstances that have the greatest influence on carbon tax design. As with the discussion of policy objectives, the specific implications of different circumstances will be discussed in the subsequent chapters on specific elements of carbon tax design. The intention of this section is to identify the key factors and prepare policy makers to consider these factors from the outset. Early consideration will be particularly important for factors that are not immediately obvious, and therefore require further investigation.

3.3.1 Government capacity and rule of law

Administering a carbon tax is typically simpler than administering an Emissions Trading System (ETS) (section 2.3.2), and some carbon tax designs may require significantly less administration than many other taxes. Effective administration does nonetheless require that adequate capacities be in place in areas such as tax administration and enforcement, while some tax design options may also require capacities in emissions Measuring, Reporting and Verification (MRV) or in the administration of complementary programs (section 9.2) It is therefore important for jurisdictions to understand government capacities and the overall level of governance in key areas of tax administration, and identify any existing issues relating to non-compliance with tax obligations (e.g., smuggling and tax evasion).

The determination of the requisite capacity needs and whether these are met by current systems has to be based on the specific needs of different design elements and options. For example, applying the carbon tax to certain

Box 7. Implications of Government Capacity and Rule of Law for Carbon Tax Design

ISSUE	IMPLICATIONS	SEE FURTHER
Tax base	Upstream taxes on fuels are typically far simpler to implement than taxes on other products or processes, and so jurisdictions with lower capacities might consider applying taxes only to fuels rather than to industrial processes or waste, for instance.	Chapter 5
Use of offsets, exemptions, and rebates	Administering offset and similar programs can be administratively complex and present opportunities for gaming the system. Such programs may therefore be challenging for jurisdictions with low overall capacities. Exemptions and rebates are, by contrast, relatively easy to administer. However, they do require a minimum level of tax administration capacities and can erode the price signal of the tax.	Chapter 7, 8, and 9

sectors only will require more complex MRV systems, and adopting features such as offsets or conditional rebates will require additional administrative capacities. Studying the experience of jurisdictions with similar circumstances and speaking to counterparts in those jurisdictions can also help to understand how these needs play out in practice. Where it is not obvious whether existing country capacities match up to the needs of given design options, governments can use a range of capacity needs assessment tools to support this assessment,[25] and can integrate capacity building into the design of the carbon tax (section 9.2.4).

3.3.2 Emissions profile and economic context

The economic structure of the economy as a whole, and key emitting sectors in particular, has a substantial influence on how a carbon tax will affect the economy, generate revenue, and result in GHG emission reductions. It is therefore a central factor for jurisdictions to consider in determining whether a carbon tax makes sense and in selecting the right design options. Carbon taxes are classic market instruments, and so the effects they have depend on how the market in question works. In general terms, the price signal provided by a carbon tax will have greater mitigation effects in liberalized markets with highly elastic demand. Another relevant consideration is what other policies are in place in the sector—for example, subsidies for fossil fuels or agriculture—and the effects these have on the price signal (section 2.3.4). Before engaging in the details of carbon tax design, it is worthwhile for jurisdictions to do some preliminary data gathering and economic analysis. The following sets out some of the key economic and emissions data that can help inform decision making.

3.3.2.1 Emissions profile and trends

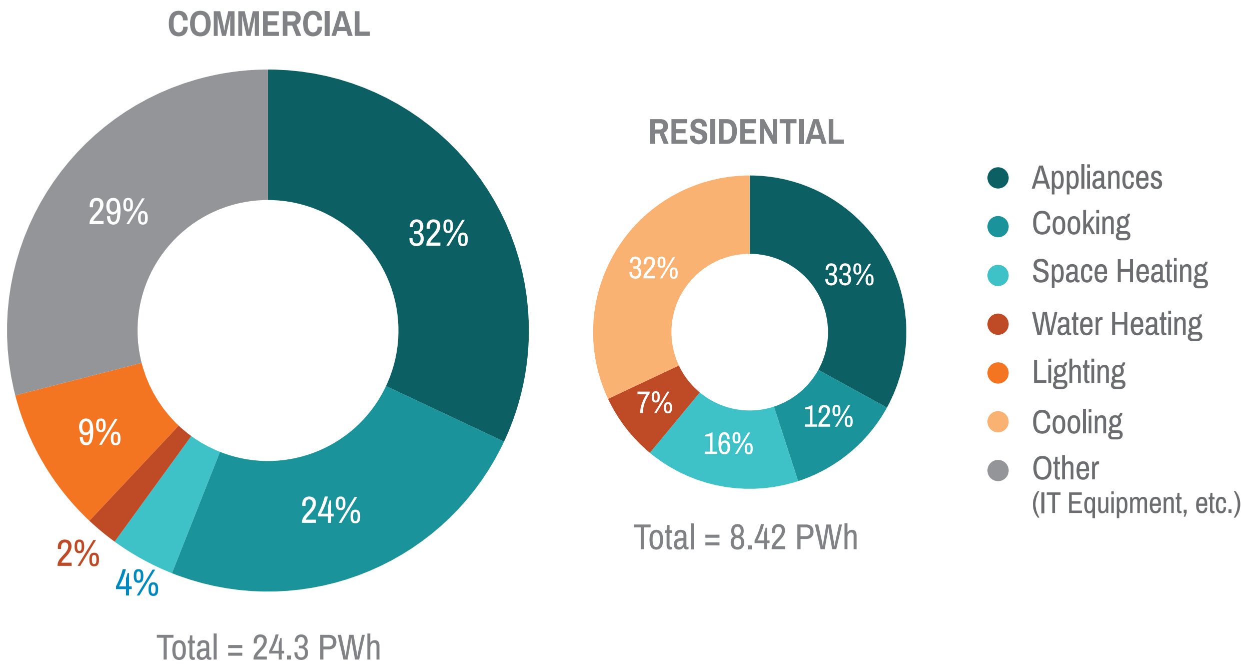
Mapping GHG emissions in the jurisdiction is central to determining where the largest amount of emissions is released, and therefore where the tax is likely to have the biggest impact on emission reduction and revenue raising. Jurisdictions' emissions can be broken down by economic sector or by emission sector as defined by the Intergovernmental Panel on Climate Change (IPCC) (2014). Since most countries submit at least biennial reports to the UNFCCC that show the distribution of emissions across sectors and in many cases also subsectors, these reports can provide crucial input to help identify where the major emission abatement opportunities lie.

The more disaggregation is possible in mapping emissions, the more useful it will be for policy makers deciding on what—more specifically, which actors, products, and/or activities—to direct the carbon tax at. For example, where it is possible to break down residential and consumer energy use (figure 8), this can help policy makers determine which fuels or fuel users to target.

Understanding emissions trends over time and projections for the future is also important for enabling policy makers to target the tax so as to limit emission increases. All developed ("Annex I") countries and some developing countries have been measuring emissions for some time and so have relatively reliable information to base trends on. Many developing countries have also developed BAU projections as the basis for the targets included in their NDCs, and these targets can also provide valuable input for carbon tax design.

[25] A range of such tools have been developed by international organizations such as the Asian Development Bank, the Global Environmental Facility, and the International Monetary Fund (see further reading below).

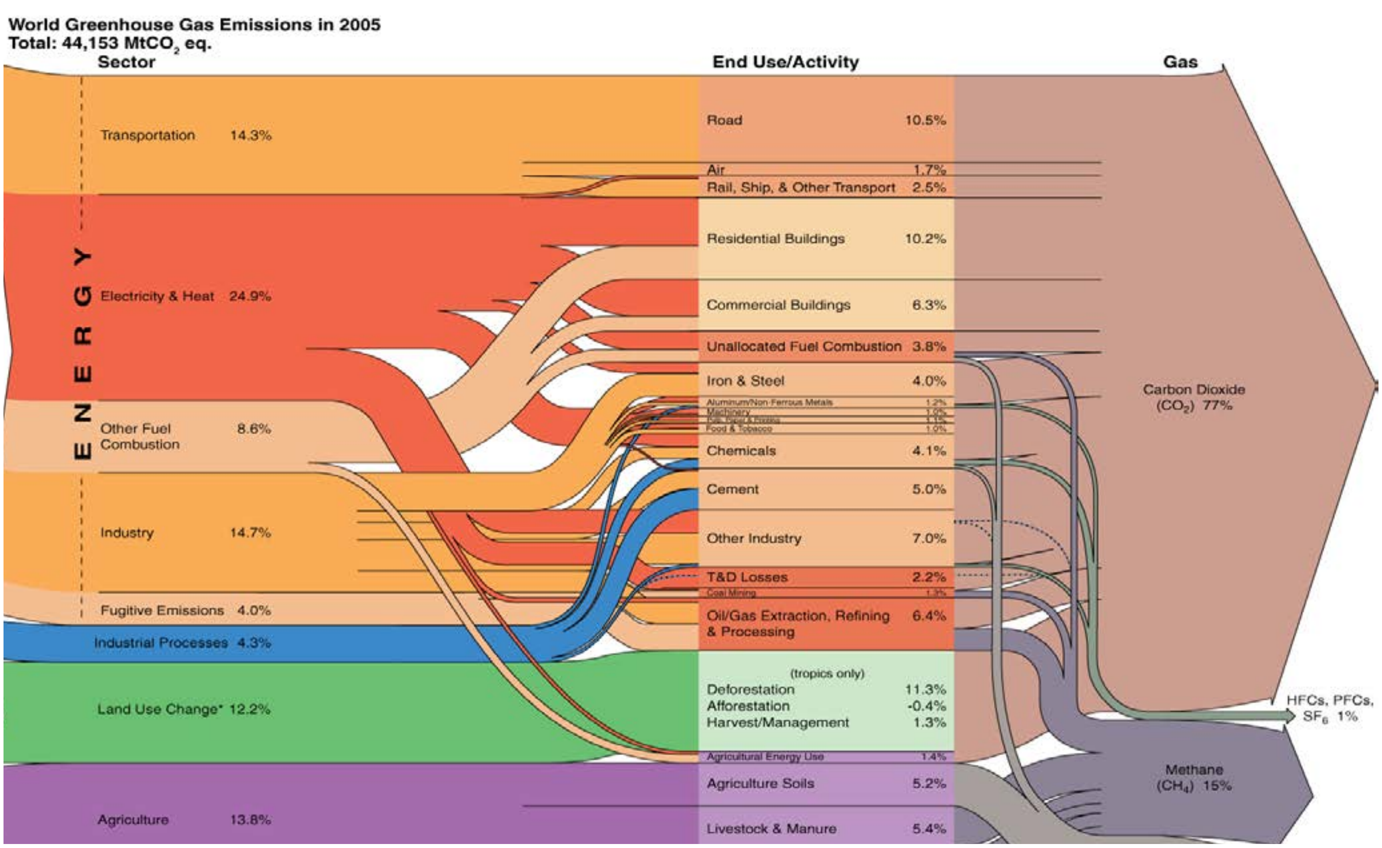
Figure 8. Relative Global Use of Energy in 2010



Source: IPCC 2014.

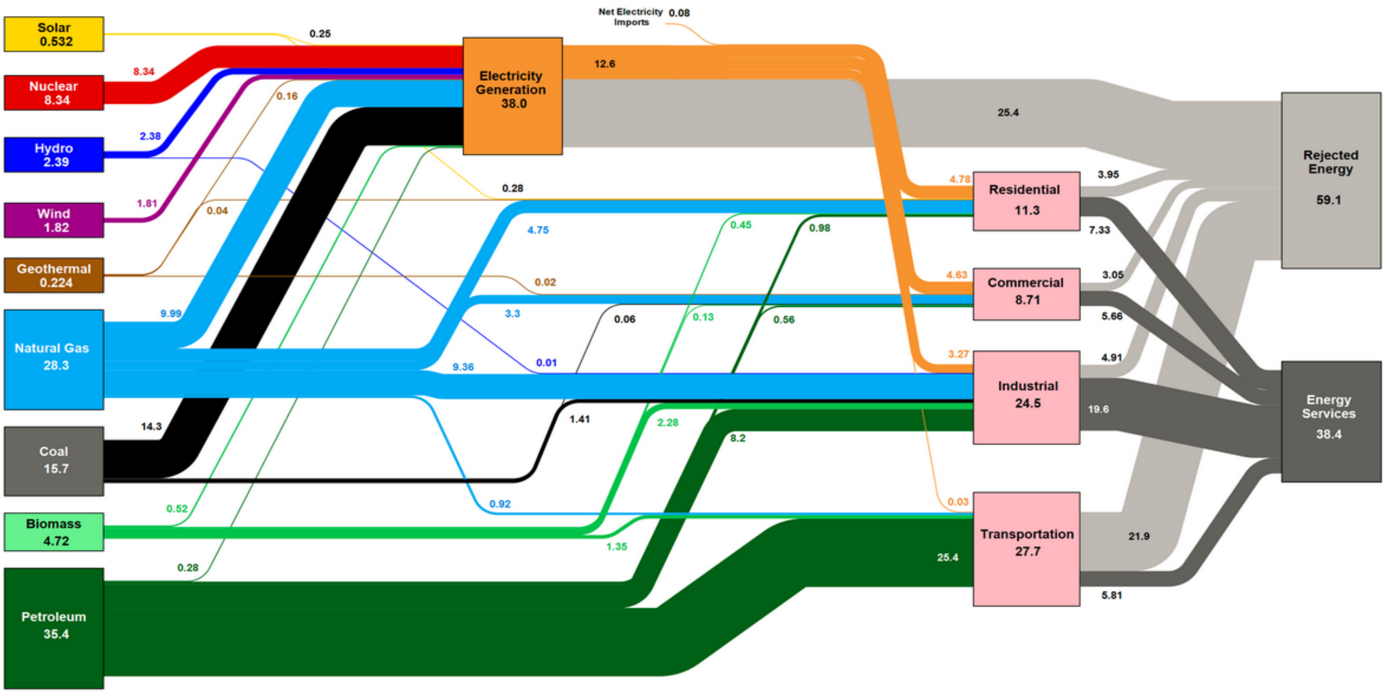
Note: AFOLU = Agriculture, Forestry, and Other Land Use.

Figure 9. Sankey Diagram of World GHG Emissions by Sector, End Use, and Gas in 2005



Source: World Resources Institute 2017.

Figure 10. Sankey Diagram of Estimated Energy Consumption in the United States in 2015 (Quads)



Source: Lawrence Livermore National Laboratory and the U.S. Department of Energy 2016.

3.3.2.2 Analyzing the dynamics of key sectors

Besides analyzing the national inventory on a sectoral and subsectoral basis, it is useful for jurisdictions to analyze in more detail the structure of key sectors, assessing the different activities and gases connected to each. This can be accomplished using a Sankey diagram that illustrates connections between a range of different factors and processes, such as between activities and emissions (figure 9), or between sources of energy and their end uses (figure 10).

This disaggregation of emissions from specific activities and sources of energy can provide useful insights into the implications of particular carbon tax designs, not only in terms of determining optimal coverage, but also in setting the point of taxation, the level of reporting obligation, and possible thresholds. Understanding energy flows is also important when considering the relationship of the carbon tax with other policy objectives, such as those related to energy, industrial and transport policy. For instance, in figure 10, a tax on petroleum products would mostly affect industry and transport emissions, which would align both with reducing emissions in these sectors and in incentivizing modernization in industry and the development of the market for low-emissions transport.

3.3.2.3 Economic structure of key sectors

Carbon taxes work by sending a price signal to businesses and consumers to change their behavior in a way that reduces emissions. As such, they work best in sectors that are responsive to price signals (section 2.3.4). Some jurisdictions have therefore introduced carbon taxes together with broader liberalization of the energy sector (box 8).

To better understand the potential impact of a carbon tax on emissions, jurisdictions can engage in economic analyses, which can range from a very simple analysis of the elasticity of demand in key energy markets to advanced modeling

Box 8. Case Study: Liberalization of the Mexican Energy Market and the Carbon Tax

The Mexican government introduced a carbon tax on fossil fuels in 2013 in conjunction with wider fiscal and energy sector reforms. In December 2013, the Mexican Congress approved constitutional amendments that ended the state monopolies of electricity and petroleum to encourage private investment. A series of related laws were passed in August 2014, and investments in the energy sector rose to US$2.4 billion in 2014. This was key to the decision to introduce a carbon tax, since in a monopolized market the price signal would have had little effect and more command and control type of regulation would have made more sense.

Box 9. Implications of Emissions Profile and Economic Context for Carbon Tax Design

ISSUE	IMPLICATIONS	SEE FURTHER
Tax base	To have a tangible effect on reducing emissions, the carbon tax could be focused on sectors that have been liberalized and characterized by elastic demand.	Chapter 5
Tax rate	Where the government seeks a given mitigation outcome in the energy sector, a range of characteristics of the energy market can be modeled to help determine the optimal tax rate. Knowing the cost of available mitigation options in these sectors can also help determine the rate.	Chapter 6
Addressing leakage	Factors such as the interconnectedness of the energy market and the trade exposure of key sectors affect the likelihood of leakage.	Chapter 7
Use of revenues	Government revenue raising generally distorts prices and imposes costs on the economy. Governments should carefully consider how they use the revenue from carbon taxes, including the opportunity to reduce other distortionary taxes.	Chapter 8

of the entire economy that captures the interaction across sectors (called general equilibrium modeling). Chapter 4 provides further guidance on using modeling to support carbon tax design.

3.3.3 Political feasibility and state of public opinion

In jurisdictions with high public concern over climate change and support for green industry, carbon taxes can enjoy significant public support. However, carbon taxes can be unpopular in jurisdictions where addressing climate change is a lower priority, and in these cases it may be challenging to muster the required political and public support. It is therefore worthwhile for jurisdictions to conduct a general assessment of the political climate before deciding to move forward with carbon tax adoption, as well as continuous assessments throughout the process of designing, adopting, and reviewing the carbon tax.

The most effective way to both assess the state of political and public receptiveness to a carbon tax and foster greater acceptance is to implement a broad and in-depth stakeholder engagement process. Engaging stakeholders at an early stage can serve to understand their concerns and map areas of support and opposition, including the sectors that are likely to be more or less resistant. The most effective stakeholder engagement process makes use of a variety of tools, including inviting written submissions and organizing face-to-face meetings and working groups. Ideally the process should be inclusive and transparent, and involve different political parties, key industries, the

Box 10. Case Study: Stakeholder Engagement in Designing the South Africa Carbon Tax

South Africa's proposed carbon tax covers multiple sectors and a large portion of the country's emissions. It was therefore key to ensure broad and effective stakeholder engagement to gain the support needed for the tax to be adopted.

South Africa involved stakeholders in the carbon tax design process through a number of channels. On the one hand, an Intergovernmental Committee on Climate Change and a number of Technical Working Groups have helped to involve government stakeholders from different departments and ensure a coordinated position. A broad range of nongovernmental stakeholders—including key businesses, civil society groups, labor unions, and academia—were meanwhile involved through the National Climate Change Committee. In parallel, stakeholders were given the opportunity to comment through written submissions on multiple iterations of the design of the carbon tax, including the Carbon Tax Discussion Paper, the Carbon Tax Policy Paper, and the draft legislation and implementing regulations.

Box 11. Implications of Political Feasibility and Public Opinion for Carbon Tax Design

ISSUE	IMPLICATIONS	SEE FURTHER
Tax base	In sectors that are influential, well-organized, and where substantial resistance exists to climate policy, introducing a carbon tax will be more challenging and an effective stakeholder engagement strategy will be needed.	Chapter 5
Tax rate	In jurisdictions where there is less support for climate action, introducing the tax at a low rate—at least at first—may be more acceptable.	Chapter 6
Use of revenues	Revenue-neutral options can increase acceptability where this is lacking, as can directing revenues to rebates or social programs. Redirecting revenues to areas of high political importance in the jurisdiction (e.g., job creation and protection of vulnerable segments of society) can be especially effective in increasing acceptability.	Chapter 8

media, NGOs, and citizens' groups. At the same time, as the process evolves, it will become necessary to deal with those whose support is particularly important to passing and implementing the carbon tax.[26]

3.4 PRINCIPLES OF CARBON TAX DESIGN

As discussed in the previous sections, jurisdictions can prepare for the carbon tax design process by identifying and prioritizing their objectives, and by clarifying the salient elements that define the national context for the new tax. In addition to this, it is useful for governments to have a set of criteria to evaluate alternative carbon tax designs that will meet their policy objectives.

To aid governments as they evaluate the merits of alternative designs, the OECD and World Bank (2015) have developed a set of principles to guide carbon pricing design generally—the FASTER principles:

- Fairness
- Alignment of policies and objectives
- Stability and predictability
- Transparency
- Efficiency and cost-effectiveness
- Reliability and environmental integrity

These principles, which are broadly organized around the concepts of cost-effectiveness and feasibility, can be used in the design process. The subsequent chapters of this Guide will highlight ways in which the FASTER principles can be practically applied and demonstrate how they can be integrated into the design process.

[26] See further PMR & ICAP, 2016.

Some of the criteria of the FASTER principles relate to environmental and social circumstances. "Fairness" and "transparency" address political feasibility or acceptability and social impacts. "Alignment of policies and objectives" and "reliability and environmental integrity," meanwhile, address issues of environmental efficacy.

The other criteria are more closely related to the economic costs of the policy tool choice and design. "Cost-effectiveness" generally refers to the capacity to reach a specified target at the lowest cost possible, while "efficiency" refers to the capacity to select a target that balances environmental benefits and the costs of emission controls. Cost-effectiveness is often divided into static and dynamic cost-effectiveness: the capacity to induce adoption of low-cost technologies in the short run and to encourage innovations to further lower costs in the long run. Cost-effectiveness incorporates the overall costs to the economy of the tax as well as its administrative costs.

"Stability and predictability" refer to the capacity to facilitate a smooth transition of the economy as the environmental program is implemented. To this, a few analysts have added the need for the government to be able to credibly commit to the tax into the future. Unstable taxes (or other policy instruments) that are highly sensitive to political swings will not effectively induce investment in environmental protection or energy efficiency.

Each of these elements relates to specific principles that governments can use to guide their specific carbon tax design. Table 11 presents some examples of questions that take the principles from the general to the specific. However, policy designers will need to customize the application of the principles to their jurisdiction's specific contexts, including their social values, priorities, and circumstances. They will also need to balance and prioritize certain principles in cases where these conflict. For example, in examining the fairness principle, a country that has embraced the "polluter pays principle" in its legislation or policy may place more emphasis on this, for example by seeking to ensure that the tax targets the largest polluters and by limiting exemptions and other flexibilities. However, where targeting some major emitting sectors poses technical or administrative challenges, this may not prove to be cost-effective.

The FASTER principles are not necessarily exhaustive, but do provide a solid foundation for examining tax design options. Some jurisdictions might decide to add other criteria. For example, legal feasibility may be relevant to determining whether a particular design option is permitted by relevant national laws and administrative structures. Jurisdictions with multitier tax systems that share control between national, regional, and local tax authorities might also want to consider this factor as they develop their criteria for evaluation of alternative carbon tax designs.

Perhaps most important for consideration of the merits of carbon taxes and evaluation of their specific design is to understand the costs (and benefits) they can bring to a nation's system of public finance. Revenue-raising policy tools such as carbon taxes have fundamentally different

Table 11. Example Evaluation Questions Based on the FASTER Principles

FASTER PRINCIPLES	EXAMPLE EVALUATION QUESTIONS
Fairness	• Is the tax design consistent with the "polluter pays" principle or a similar approach? • How are the costs of compliance distributed among consumers and industries, across income groups and between private parties and the government? • Will the economic burden fall unfairly on low-income households? • Will energy-intensive industries be placed at a significant disadvantage as they compete in international markets?
Alignment of policies and objectives	• Will the tax design promote the jurisdiction's key objectives? Will it be effective? • Will the tax design have counterproductive effects related to other policy goals (such as improvements in energy security, reductions in water use, preservation of habitat)?
Stability and predictability	• Is there a strong likelihood (given the jurisdiction's legal and political context) that adopted policies will be overturned in the future? • Will private parties be willing to make investments based on the jurisdiction's policies? • Is there a sufficiently clear indication of how the tax rate will develop over time to allow investors to undertake long-term planning? • Can the tax be altered if there is a perceived policy justification? Does that adaptability undermine the tax's value as an incentive mechanism?
Transparency	• Will the public understand how the policy instrument works? • Will the public be able to understand the distribution of costs and benefits arising from the instrument? • Is the tax sufficiently transparent to allow the public to monitor progress?
Efficiency and cost-effectiveness	• Will the tax provide an incentive to adopt cost-effective practices to lower emissions? • Will the design encourage technical innovation? • Will the government's information requirements and implementation costs be reasonable? • Will private parties incur high transactions costs to report their emissions? • Is the tax (and related initiatives) sufficiently broad to cover all major abatement opportunities?
Reliability and environmental integrity	• Will the covered sectors try to lower their emissions in response to the tax? By how much? • Will the tax (and related initiatives) result in the country meeting its GHG abatement goals? • Will emission reductions be lost to leakage? • Does the design of the tax minimize opportunities for tax evasion? • Are the monitoring, reporting and verification (MRV) requirements adequate to assure the integrity of the system?

impacts than instruments such as subsidies or direct government action. This actually is a critical element of the so-called “double dividend” effect (see chapter 8). While this criterion is arguably embedded in the efficiency and cost-effectiveness FASTER principle, jurisdictions might want to add a specific criterion related to the impact of the carbon tax on the social cost of the nation’s tax system.

Key Considerations

- Having a clear picture of the different policy objectives the government seeks to achieve with the carbon tax, while also understanding their relationships and being able to prioritize between them, is important for guiding the decision-making process. Cross-government consultation can help to align and prioritize objectives across different ministries.
- To understand how the carbon tax can contribute to mitigation of GHG emissions, it helps to have a clear idea of the specific emission reduction or abatement target of the jurisdiction and the role of the carbon tax in meeting those targets. It is equally important to understand the emissions profile of the jurisdiction and the value chains in key sectors.
- As a carbon tax works through the price signal, it is important to understand the economic characteristics of key sectors and the level of responsiveness to price signals.
- Having a clear picture of the government’s capacities in key areas is important for informing a number of design decisions. Where this is unclear, capacity assessments can help inform decision making.
- Gaining a thorough understanding of the political landscape early on, including the main areas of support for and resistance to a carbon tax, is crucial for informing both the substantive design of the tax and the design of an effective stakeholder engagement process.
- The FASTER Principles for Successful Carbon Pricing can serve as a valuable tool to guide the evaluation of potential carbon tax design options

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4 MODELING CARBON TAXES

At a Glance

The process of designing a carbon tax raises many technical questions, ranging from which policy instruments are likely to be most effective in reducing GHG emissions to how specific sectors (or the economy as a whole) are likely to respond to a carbon tax and what effects can be expected in terms of emission mitigation, revenue generation, and social and economic impacts.

Many types of analytical tools are available to help policy makers explore these questions, ranging from simple cost curves to sophisticated economic models. By providing insights into the relative effects of different options, these tools can provide useful input for decision making. At the same time, it is important to keep in mind that models are subject to a number of limitations and should be seen as only one of several inputs for the decision-making process.

Among these models there are two common distinctions:

- **Partial/focused approaches vs. systemic approaches.** Some models focus on specific industries/sectors of the economy or on specific sets of technologies or practices. Others attempt to capture the interaction of many different elements of the energy-economy system by taking a system-wide approach.
- **Top-down vs. bottom-up approaches.** Top-down models are those that depict the responses of economic actors or the economy as a whole. Bottom-up models focus on technologies and practices instead.

Given these two distinctions, four basic approaches to modeling can be identified, although many variations within each category exist and some models cross categories.

- **Partial equilibrium models are top-down models** that focus on a specific industry or sector. While they do not capture the interaction among the various parts of the economy, they can be very useful for understanding how a carbon tax would affect a specific part of the economy.
- **Engineering cost models are bottom-up models** that focus on identifying and comparing specific practices and technologies. They are particularly useful for identifying the potential costs and contributions of particular technologies and practices available to reduce emissions.
- **Energy-economy models** are top-down models that depict the entire economy. A wide variety of these models exist. Some of the most common are:
  - **Econometric models** that are based on statistical analyses of past economic relations. They are particularly useful for evaluating the impact of carbon taxes on macroeconomic performance indicators such as Gross Domestic Product (GDP), employment, and consumption.
  - **Computable General Equilibrium (CGE) models,** which are designed to capture (i) the ways in which economic actors adjust their behavior to changes in prices and (ii) the interactions of many parts of the economy. These models are particularly useful for estimating the level and distribution of costs of a carbon tax.
- **Energy system models** are bottom-up models that can help to identify the combination of technologies that can meet a jurisdiction's energy demand at the lowest cost. These models are most useful for examining the potential to meet mitigation targets and for understanding how the technology mix might adapt to a carbon tax.

In determining whether to use modeling and, if so, which models to use, it is important that jurisdictions first identify the questions they want answered. Different models can provide different insights, and taking multiple approaches can help provide insights into a range of relevant factors. Policy makers also need to consider their resources for the modeling process—particularly available funding, personnel skills, and data—and plan ahead, especially in the case of more complex models.

4.1 INTRODUCTION

As policy makers consider options to reduce greenhouse gas (GHG) emissions, raise revenue, or other policy objectives, they will need to evaluate alternative policy instruments used individually or in combination. If they decide to develop a carbon tax, they may want to forecast the potential impacts of their design options. Once a carbon tax has been implemented, jurisdictions will have to periodically evaluate the impact the tax has had in practice and consider options for revising the tax.

Several modeling tools can be used to address these questions; they vary in design, application, and complexity. To choose among them, policy makers need to determine in detail what questions they want the tools to help answer. Once these questions have been clearly identified, policy makers can assess the suitability of alternative modeling approaches.

The purpose of this chapter is to help policy makers understand the various modeling approaches and tools available, and to assess which might be most suitable to address specific questions that arise throughout this Guide. This chapter has been structured in such a way that it can easily be used in combination with the other chapters of this Guide, supplementing the substantive discussion on design options and decisions with more detailed guidance on tools available to support those decisions.

A few caveats may aid the use of this chapter. First, it is not strictly necessary to model the assumed impacts of a carbon tax ex ante. If modeling resources are not available, government agencies may choose to phase in a carbon tax over time and monitor its impacts. The initial carbon tax rate can be based on that of other countries or on the social cost of carbon. Second, modeling is inherently limited by the quality of the inputs entered into the model. Most models make a number of assumptions, many of which will have a significant impact on the results of the model. Consequently, all models have a degree of uncertainty, and model results should be interpreted keeping in mind this uncertainty.

However, in many situations, models can illuminate important trends or provide analyses of regulations that are being implemented for the first time. Models are particularly strong at comparing policy options quantitatively to yield qualitative conclusions about which option is the most appropriate for a given context.

The chapter first discusses the decisions that modeling can help support and the specific questions it seeks to answer (section 4.2). It next provides a high-level overview of modeling approaches (section 4.3) before describing them in more detail (sections 4.4 and 4.5). Finally, it provides guidance on choosing between the different approaches available (section 4.6).

4.2 USES OF MODELING ANALYSIS

Modeling can support policy makers throughout the carbon tax design and implementation process, first by facilitating the comparison of alternative policy instruments (chapter 2), next in the design of carbon taxes (chapters 5 to 8) and the evaluation of specific national circumstances (chapter 3), and finally in the post-implementation evaluation of observed performance (chapter 10).

Throughout the chapters of this Guide dealing with these design and evaluation questions, reference is made to where and how modeling can support decisions. The purpose of this section is to provide an overview of these decisions—indicating the parts of the Guide where they are discussed in detail—and in each case identifying the specific questions that modeling can provide insights into and support for. It is worth noting that the range of questions that can benefit from some form of modeling may vary substantially, depending on the stage of the design process and the specific context of the jurisdiction.

A preliminary consideration of the types of questions that policy makers might face are summarized in table 11, and referenced throughout the chapter.

4.3 OVERVIEW OF MODELING APPROACHES

Various analytical tools and approaches may be used to examine each of the questions set out in section 4.2. The range of tools is very wide, so this chapter focuses on the modeling tools that are most useful in answering the issues identified above.

Choosing the correct tool is crucial: when modeling the connections between energy and the economy, the choice of model has profound impacts on results (Jaccard et al. 2003; Rivers and Jaccard 2005).

Those tools, and the approaches to their use, can be differentiated in several ways:

- **Partial vs. systemic analysis.** Some models focus narrowly on specific activities, technologies, markets, or industries. Others are designed to capture the interactions across entire economies, energy systems, or both.
- **Top-down vs. bottom-up analysis.** Traditionally, researchers have had to choose between "bottom-up" models, often employed by environmentalists, engineers, or physicists, and the "top-down" models often preferred by economists. Top-down models depict market behavior in response to price changes—for instance, how the quantity of energy demanded responds to changes in price. Bottom-up models emphasize

engineering cost analysis of specific technologies; the underlying assumption is generally that economic actors will choose the lowest-cost option.

- **Domestic vs. international analysis.** Many models focus on individual jurisdictions. For some applications, however, it is necessary to capture interactions among jurisdictions. Models vary in the geographic scope of their coverage, ranging from local to global.
- **Ex ante design vs. ex post evaluation analysis.** Policy makers use ex ante analysis to evaluate the expected effects of various carbon tax designs. They will typically also want to assess the impacts of the carbon tax after it has been in place for a year or more (chapter 10). At

Table 12. Summary of Ways That Modeling Can Support Decision Making on Carbon Taxes

CHAPTER	TOPIC	HOW MODELING CAN SUPPORT DECISION MAKING
Chapter 2	Comparing carbon taxes with other instruments	Assessing the relative performance of alternative policy instruments for reducing GHG emissions Evaluating how a carbon tax will interact with other policy instruments and reforms
Chapter 3	Evaluating the broad impacts of alternative taxes	Evaluating the economic costs/benefits of a given carbon tax design Evaluating how the costs and benefits of a carbon tax would be distributed across various income groups, geographic regions, and economic sectors in the jurisdiction Predicting the environmental benefits of a carbon tax not related to GHG emissions Estimating changes in GDP resulting from different tax rates Evaluating compatibility with FASTER principles such as fairness, cost-effectiveness, and efficiency
Chapter 5	Determining sectoral responsiveness to carbon tax	Evaluating the potential contribution to emission reductions from alternative technologies and practices Estimating specific changes in economic sectors in response to a carbon tax Evaluating the impact of alternative sectoral coverage arrangements Estimating changes in consumption of specific fossil fuels in response to a carbon tax Forecasting technological changes deriving from a carbon tax
Chapter 6	Effects of tax rate decisions	Estimating emission responses to different carbon tax rates Estimating revenue arising from different carbon tax rates
Chapter 7	Assessing potential effects on leakage and distribution of the costs	Estimating the extent of leakage likely to arise from the carbon tax Estimating the expected distribution of cost associated with the carbon tax Evaluating the effectiveness of leakage mitigation measures or measure to address distributional concerns
Chapter 8	Modeling the effects of options for revenue use	Estimating the current marginal cost of public funds and the relative marginal cost of various types of tax Estimating the value to the economy of substituting a carbon tax for other revenue-raising mechanisms
Chapter 10	Ex post analysis of impacts	When conducting an ex post analysis of the impacts of the carbon tax, many of the issues listed above could be addressed retrospectively rather than prospectively. Again, various models and tools are available for such an analysis.

Table 13. Categories of Models

	TOP-DOWN	BOTTOM-UP
Partial/focused	Partial equilibrium models	Engineering cost studies
General/systemic	Econometric and computable general equilibrium (CGE) models	Energy system optimization models

this point, decision makers ask many of the questions listed in table 12, but frame them in terms of what was the observed change rather than the expected change.

Of these dimensions, the first two are the most commonly used to differentiate the model types or methods (table 13). Some researchers have also developed approaches that combine bottom-up engineering models with top-down economic models to form hybrids that draw on the strengths of each.

The latter two are more related to how the models are applied. The choice among modeling options will largely be determined by which questions policy makers are asking. The following sections describe the most important forms of modeling in more detail.

4.4 PARTIAL ECONOMIC AND TECHNOLOGY MODELS

Partial models are those that focus on a specific market, activity, or technology. This section discusses two broad types of partial models: (i) partial equilibrium models designed to depict how markets respond to changes in prices and (ii) partial equilibrium models that model how specific technologies or practices could contribute to emission reductions (known as "engineering cost studies").

4.4.1 Partial equilibrium models

Partial equilibrium models are designed to examine the effects that economic changes, such as the introduction of a carbon tax, will have on particular markets.

Best uses of partial equilibrium models:

- Modeling the response of how consumption of specific fuels will respond to a carbon tax, particularly in the case of a relatively low tax.
- Generating approximations of how energy use will broadly respond to a carbon tax.
- Comparing the responsiveness of different fossil fuels to an energy tax and determining the most responsive one.

4.4.1.1 How partial equilibrium models work

Partial equilibrium models provide a tool to analyze the effects of price changes (such as those resulting from a carbon tax), resource availability, and other policy instruments within a limited segment of the economy. They generally use historical supply and demand elasticities (box 12) to determine how key elements of the economy such as the electricity sector, the auto industry, or the steel industry will respond to changes such as the introduction of a carbon tax.

By focusing on a specific industry or sector, a partial equilibrium model provides a relatively detailed representation of the factors and impacts that act directly on the subject industry or sector, though they do not usually capture indirect effects. For example, a partial equilibrium model of the impact of a carbon tax on the auto industry might capture the direct effect of the cost of energy on the manufacturing process and the shift in demand toward more energy-efficient vehicles, but not the second-order effects on the price of steel or the change in consumer income that could shift the demand curve.

Partial equilibrium models are important tools for understanding the relation between prices and levels of supply and demand. In the context of carbon taxes, partial equilibrium models are most commonly applied to energy markets; however, they could also be applied to industrial emissions, agricultural practices, and virtually any market where the price effect of a carbon tax could shift the costs of production or consumption. Understanding this relationship is critical in setting the carbon tax rate since it determines the effects that different tax rates will have on consumption, which in turn affects the amount of emissions that will be reduced and the revenue that will be raised.

For example, while a very basic approach to estimating carbon tax revenues might be to simply multiply the carbon tax rate by the amount of carbon currently emitted in the covered sectors or activities, this approach does not capture the effects of adjustments in producers' and consumers' behaviors in response to the tax. Partial equilibrium models enable policy makers to factor this key variable into their assessments.

To capture the relation between price and consumption, policy makers need to identify the demand elasticities of key sectors (for a given good, the ratio between percent

Box 12. Technical Note: Price Elasticities of Demand

Price elasticity is a measure of how responsive the quantity demanded is to changes in price. Specifically, price elasticity, ε, is expressed as:

$$\varepsilon = (\Delta Q/Q)/(\Delta P/P)$$

or price elasticity is equal to the ratio of percent change in quantity to percent change in price (Δ is the symbol for "change" or "difference").

In general, when the price of a market good rises, the quantity demanded drops. Thus, price elasticities are expected to be negative. When ε is between 0 and -1, demand is referred to as "inelastic," meaning that the relative decline in quantity is smaller than the rise in price. When ε is equal to -1, it is referred to as "unit elasticity," meaning the change in quantity perfectly matches the change in price. And when ε falls beyond -1 (that is, is more negative), it is called an "elastic" demand, indicating that the magnitude of the change in quantity is relatively greater than the change in price.

changes in the quantity demanded and percent changes in its price (box 12)). Estimates of elasticities are based on actual observed changes, generally in response to natural fluctuations in prices over time. Estimates vary across jurisdictions, fuels, and income groups (table 14). A carbon tax is likely to provide incentives to switch toward a low-carbon fuel mix; these elasticity-based estimates provide a first approximation of the impacts of a carbon tax on consumption levels.

In the very simplest model, where domestic demand does not affect the price of a good (as, for example, may be the case of oil, where the supply cost is determined on the world market), the percent change in the quantity of the good demanded will simply be the product of the elasticity and the percent change in the price of the good caused by the introduction of the carbon tax.

Because adjustments to changes in price can take time—years in some cases, such as when shifts in automobile fleets or changes in heating systems occur—it is generally recognized that demand is less elastic (responsive) in the short run than the long run. This is often reflected, as shown in table 14, by estimates for short-run elasticity, which in principle capture changes in behavior (e.g., less driving) and long-run elasticity, which capture changes in investment (e.g., switching to a more energy-efficient vehicle).

For a jurisdiction that is designing a carbon tax to cover all energy sources, this approach requires that the impact of the carbon tax on each major energy source—oil, natural gas, coal, and electricity—be estimated separately. However, since the elasticity estimates are tied to specific markets, they will very much depend on how the market was defined and which data were used. For example, it is possible to develop an estimate of the elasticity of demand for a national electricity market, or to disaggregate that market and estimate separate elasticities of demand for different geographic regions, economic sectors (e.g., industrial, commercial, and residential), types of end uses, or demographic groups (e.g., income classes). The more disaggregated the elasticity estimates are, the more data and calculations will be required.

Box 13 provides an example application of how the elasticities of demand can be used to estimate the impacts of carbon taxes on revenue, and how those revenues might change as the carbon tax rises. This example raises an important practical observation for policy makers who choose to employ partial equilibrium models: it is important to have separate estimates of elasticities of demand for all fossil fuels (and possibly for each covered sector) because these elasticities can vary significantly. It will be necessary to do separate calculations for each application.

Table 14. National Price Elasticities for Residential Electricity, Commercial Electricity, and Residential Natural Gas, United States

	RESIDENTIAL ELECTRICITY	COMMERCIAL ELECTRICITY	RESIDENTIAL NATURAL GAS
Short-run elasticity	-0.24	-0.21	-0.12
Long-run elasticity	-0.32	-0.97	-0.36

Source: Bernstein and Griffin, 2006.

Box 13. Technical Note: Estimating Tax Revenue in Agnostia

Suppose the hypothetical country of Agnostia is designing a new carbon tax. The government is interested in evaluating the impact of a carbon tax on its national revenues, starting with the income derived from residential natural gas. It has the following information:

- Annual residential consumption of natural gas: 5 billion cubic meters per year (BCM/Year)
- Current price of natural gas: US$300 per thousand cubic meters (TCM)
- Proposed carbon tax: US$10 per metric ton of CO_2
- Short-run price elasticity of demand at current price: -0.20
- Long-run price elasticity of demand at current price: -0.40

The government also has the following conversion factor:

- Metric tons of CO_2 emissions per cubic meter: 0.0169

With this relatively simple information, Agnostia's policy analysts can produce a rough estimate of the revenues from the proposed carbon tax. First recognize that the carbon tax will lead to a rise in the price of natural gas of US$169 per 1,000 cubic meters (16.9 TCO_2/TCM * US$10/ton).

The short-run elasticity indicates each one percent rise in the price of residential natural gas will entail a 0.2 percent decline in consumption (i.e., this is an inelastic demand). So,

$$-0.2 = (\Delta Q/5BCM/year)/(169/300) \quad (1)$$

Solving for the change in quantity, ΔQ, it is clear that the use of natural gas in the short run is expected to decline by 0.56 BCM/year, leading to a new annual consumption of 4.44 BCM/year (or 4.44 x 106 TCM/year). Thus, in the short run, the expected tax revenue from the residential natural gas market will be:

$$4.44 \text{ x}106TCM/year * US\$169/TCM = US\$750/year \quad (2)$$

In the long run, as residential home owners have the time to adjust to the higher prices, the elasticity is expected to shift to -0.40. Thus, equation (1) becomes:

$$-0.4 = (\Delta Q/5BCM/year)/(169/300) \quad (3)$$

The long-term reduction is 1.12 BCM/Y and the revenue calculation in (2) becomes

$$3.87 \text{ x}106TCM/year * US\$169/TCM = US\$655/year \quad (4)$$

So the revenue in the long run drops as households make additional adjustments to the higher price of natural gas, be it only slightly.

Now suppose that Agnostia is considering a rising carbon tax, as discussed in chapter 6. If the tax is in the long run allowed to rise to US$30 per metric ton of CO_2, the effective tax becomes US$507 per TCM. In the long run, equations (3) and (4) become

$$-0.4 = (\Delta Q/5BCM/year)/(507/300) \quad (5)$$

$$1.62 \text{ x}106TCM/year * US\$507/TCM = US\$821/year \quad (6)$$

While the consumption of natural gas in the residential sector drops to 1.62 BCM/year, the revenue rises to US$821M/year. This rise in revenue with higher carbon taxes is a function of the inelastic nature of the demand for residential natural gas.

Conversion factor taken from: https://www3.epa.gov/gasstar/tools/calculations.html.

4.4.1.2 Advantages of partial equilibrium models

Partial equilibrium models have several advantages:

- **Simplicity and cost.** These models can be relatively quick and inexpensive to develop, often drawing on data and information that is readily available. They are generally easy to solve.
- **Transparency.** Partial equilibrium models realistically capture the key relations between fuel use and carbon prices, but without the detailed model structure provided in CGE models.
- **Flexibility.** With a partial equilibrium model, you can plug in the responsiveness of fuel use inferred from a wide range of other models to the problem at hand. They are easy to apply to a wide range of other analyses.
- **Focus on target industries or sectors.** These models can be disaggregated to whatever level is needed for decision making, potentially providing great detail in the particular area of interest. This is useful for narrowly focused policy and impact analysis.

4.4.1.3 Limitations of partial equilibrium models

Partial equilibrium models also have a number of important limitations:

- **Indirect effects are missing.** Partial equilibrium models only look at the direct price change, as measured by aggregate estimates involving historical changes. They do not account for the effect that the price change could have on other elements of the economy—the secondary effects—which could be substantial.
- **Challenges with applying elasticities.** Partial equilibrium models generally are based on estimates of various types of elasticity. Elasticities are used to provide insights into how actors will change their behavior in response to changes in key factors, particularly prices. But using elasticities to model changes in future behavior can present challenges.
    - **Required extrapolation.** In practice, elasticities are generally estimated within a relatively narrow range of observed prices. Extrapolating from the observed range to a much broader range—as is probably necessary in the case of carbon taxes—can be problematic. These extrapolated elasticities are not necessarily good estimates of what happens when large changes in the prices occur.
    - **Historically based.** The elasticities are estimated on the basis of historical observations. Since they are a measure of the responsiveness of producers and consumers, if consumers and producers become more adaptable over time thanks to better information, lower transaction costs, or new technologies, the energy demands might become more elastic.
    - **Empirical challenges.** Estimates of elasticities show very wide ranges, indicating substantial uncertainty, even when carried out by highly competent researchers and analysts. They should thus always be used with caution and as estimates only.
    - **Many factors change at once.** Estimates of elasticities are based on the assumption that all other critical factors are held constant. However, economic theory suggests that a carbon tax will also affect the prices of substitutes like solar power and of other goods that use energy as an input for production. To also incorporate these changes into the calculation would require substantially expanding the model to include cross-price elasticities (the effect that a change in the price of one good has on the quantity demanded of another good). This would in turn lead to a substantially more challenging calculation.
    - **Policy interactions.** Using elasticities of demands alone does not allow for analyzing interactions with other policies and instruments, such as public information programs, energy efficiency regulations, and technology diffusion initiatives.

These limitations can, to some degree, be addressed by using the results of other types of models to provide measures of key variables.

- **Simultaneous actors.** When a carbon tax is applied, the cost of the energy supply will increase, leading to an increase in the price of energy. How large the price rise is depends on how participants in the market respond, particularly consumers. However, in jurisdictions with domestic energy supply, it is important to also consider the elasticity of supply and the simultaneous effect of energy producers' response.

4.4.2 Engineering cost studies

Estimates of elasticities are based on observed historical market responses to price changes. As such, they do not take into account sudden substantial changes in technology or practices. Since one of the effects of a carbon tax could be to accelerate technological changes, some simple technology-based or practice-based models are rooted in estimated costs of abatement rather than historical behavior.

Best uses of engineering cost models:

- ✓ Modeling the potential contribution that specific technologies or practices—or a set of technologies and practices—can make to emission reductions.
- ✓ Evaluating the total emission reductions that could be achieved by specific technologies or practices at a specific carbon tax.
- ✓ Evaluating the marginal and total costs of achieving a specific emissions target with specified technologies or practices.
- ✓ Evaluating the potential impact of applying the carbon tax to non-fuel sources of carbon emissions and emission reductions.

4.4.2.1 How engineering cost studies work

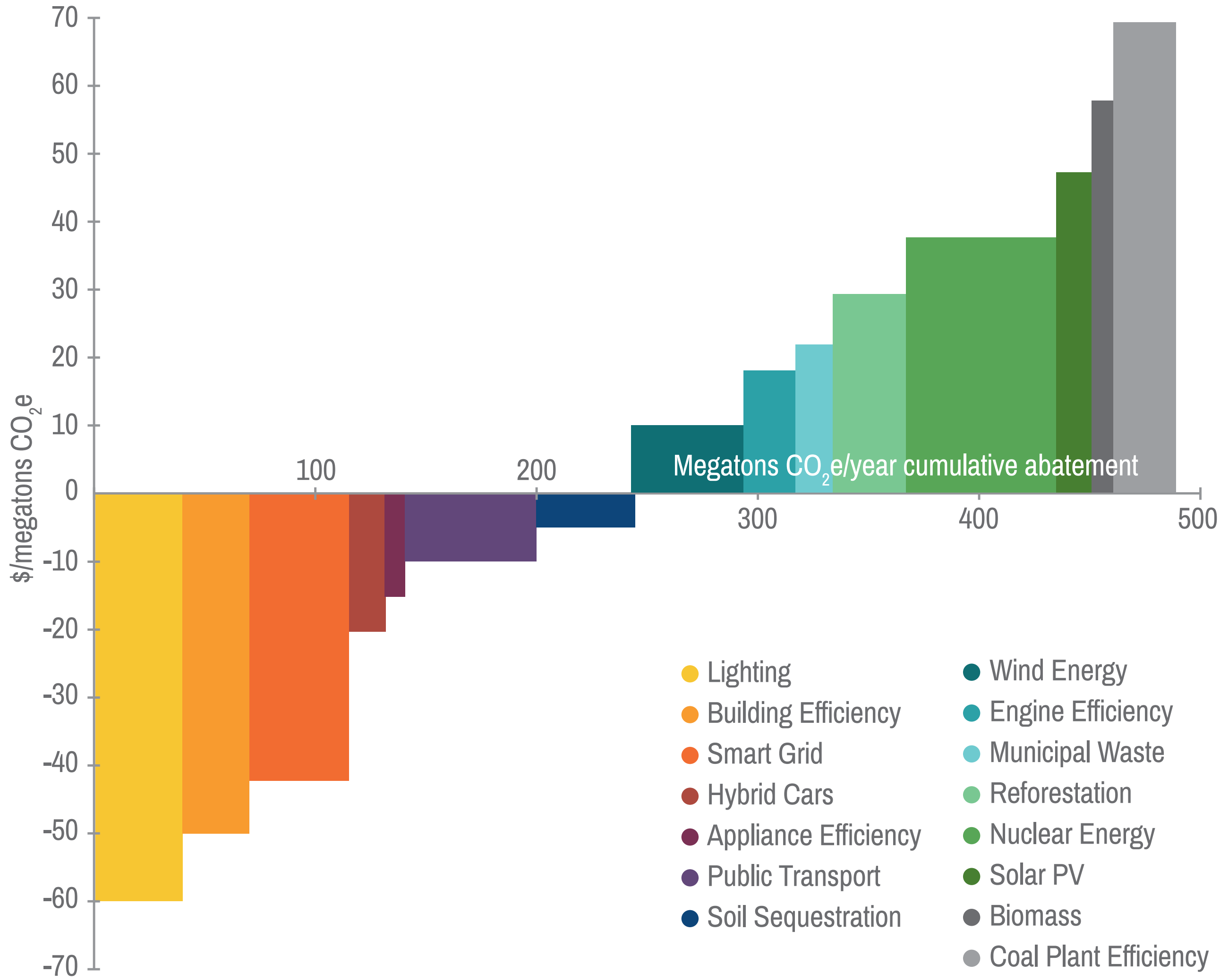
These engineering approaches to cost estimates are often referred to as “bottom-up” models to distinguish them from the economic, historically based, “top-down” approaches. They are generally developed by specialists who are familiar with the costs, performance, and opportunities for diffusion specific to the technology or practice in question.

Marginal abatement cost curves (MACCs) are derived from engineering-style analyses of the costs of individual technologies or practices. The cost of each individual practice (possibly broken down by sector or geographic region) is estimated along with the related quantity of emission reductions that is feasible. The various applications are then sorted in order from lowest to highest cost and plotted so as to sum the cumulative quantity of potential abatement at or below any specific abatement cost.

For example, the hypothetical cost curve depicted in figure 11 represents a cost curve for a number of carbon mitigation options. Producing such a curve involves several steps. First, identify the array of technical options for reducing carbon emissions, among others, expanded wind energy, improved building efficiency, and enhanced reforestation. For each technical option, estimate the potential amount of CO_2e emission reductions per year, and the average cost per ton of that reduction. To construct the graph, recognize that each technology is represented by a separate bar, where the width of the bar represents the annual GHG emissions reduction potential associated with that technical option, while the height of the bar corresponds to the average cost of reducing emissions by 1 tCO_2e with this option. The bars are then arranged sequentially from lowest to highest cost.

MACCs are a convenient mechanism to convey a great deal of information efficiently. They inform the user regarding the range of technical options available, and the relative cost effectiveness of those options. This information can help prioritize programs to concentrate first on the low-cost technical options.

Figure 11. Marginal Abatement Cost Curve (MACC) for Carbon Emissions Reduction in Hypothetical Jurisdiction



The MACC also indicate the amount of carbon abatement available below a particular price or marginal cost. In the hypothetical jurisdiction of figure 11, GHG emissions could potentially be reduced by approximately 300 tons per year for $20/t$CO_2$e or less. Note that the average cost of each successive technical option increases, depicting increasing marginal costs of abatement.

The hypothetical MACC also indicates that many of the opportunities to reduce emissions actually incur a negative cost (i.e., save money) by, for example, investing in building energy efficiency measures, appliance efficiency, and public transportation. This raises the question why these cost-saving practices have not yet been adopted. Many explanations have been offered, including the possibility that the individuals who control these activities (in many cases homeowners and industrial process managers) are unaware of these cost-saving opportunities. If that is indeed the case, it may be worthwhile linking a carbon tax with public education and technical assistance programs, among others (see chapter 2 for a discussion of complementary policy instruments).

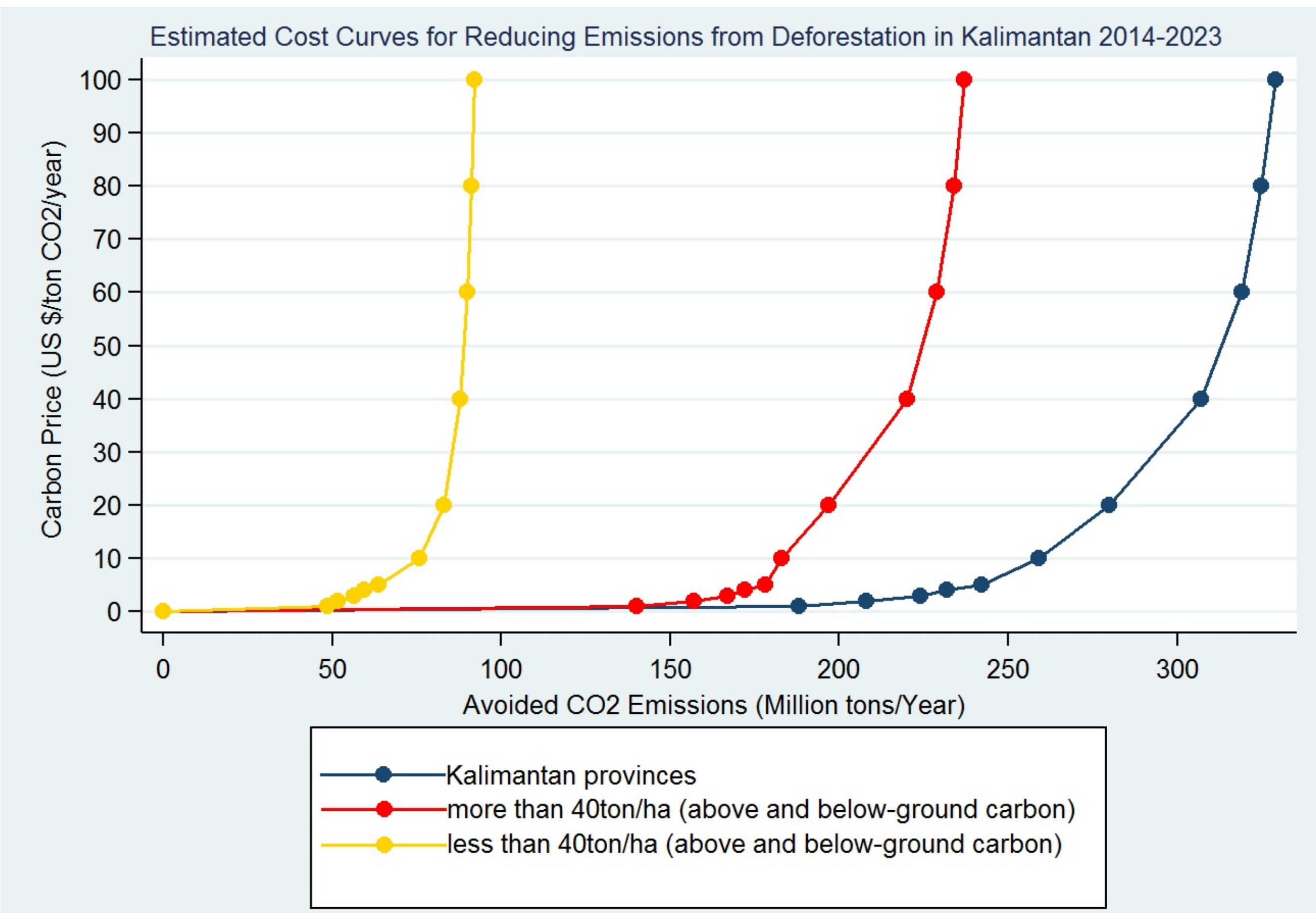
Figure 12, which depicts the marginal cost to reduce emissions from deforestation in Kalimantan, Indonesia, illustrates one of the more useful features of engineering cost analyses in which the costs are represented by MAC curves. In this figure, the two curves on the left represent the costs of GHG emission abatement with two different land types. Provided the two curves are independent (i.e., there is no overlap in coverage), they can be summed across (horizontally) to produce a total cost curve for all the options studied.

4.4.2.2 Advantages of engineering cost models

Engineering cost models have several advantages, among others:

- **Simpler to construct than complex economic models.** This approach concentrates on the direct costs of particular practices and technologies. It does not require modeling an entire economy or complex relations among different sectors.

Figure 12. Estimated MACCs for Reducing Emissions from Deforestation in Kalimantan, Indonesia (2014–23)



Source: http://blogs.edf.org/climatetalks/2015/12/23/indonesia-could-curb-deforestation-and-increase-production-with-zero-deforestation-zones/.

Note: MACC = Marginal Abatement Cost Curve.

- **Focus on specific activities.** By identifying the costs of adopting specific practices or technologies, bottom-up models help policy makers identify promising areas for government support. For example, if engineering cost studies demonstrate that energy efficiency investments are more cost-effective than investing in renewable energy jurisdictions could prioritize that approach in their spending. Similarly, if cost studies demonstrate that forest carbon sequestration is generally less expensive than options in the energy sector, but the carbon tax does not cover land use, the jurisdiction may decide to include other provisions to promote tree planting and forest conservation in its broader climate change policy.
- **Identification of potential contribution.** Cost curves demonstrate not only the costs per ton of emission reduction for a particular practice or technology, but also how those costs change as the level of deployment rises. This means that if a jurisdiction has a ceiling on the marginal cost it is willing to impose, the cost curve can indicate the potential amount of emission reduction to be derived from that particular technology or practice.
- **Transparency.** The MACCs that engineering models produce are more intuitive for many non-specialists. They can thus facilitate discussion and planning of options across a broad range of stakeholders.

4.4.2.3 Limitations of engineering cost models

While engineering cost models have the advantage of simplicity and accessibility, they also have important limitations:

- **Secondary impacts are missing.** Engineering cost studies focus on the immediate, obvious costs and potential contributions of adopting a new technology or practice. However, like partial equilibrium models, they do not generally reflect the secondary effects.
- **Reference case.** All engineering cost analyses and the MACCs that they produce are based on a comparison, that is, costs are estimated based on some reference case or baseline. However, sometimes these reference cases can be difficult to generate, particularly when the proposed action is an expansion of activities that are already occurring (e.g., wind power).

4.5 SYSTEMIC ECONOMIC AND TECHNOLOGY MODELS

The previous section described both top-down (economic) and bottom-up (technology) approaches that focused on individual markets, industries, technologies, or practices. However, these are very limited approaches that do not capture broader adjustments across economic and energy systems as prices change. Nor do these simpler models capture the distribution of impacts across income groups. For jurisdictions seeking to address questions related to interactions among taxes, the social cost implications of changes in government revenue-raising practices,[27] distributional effects, price adjustments across fuels, dynamic effects of the carbon tax, and international leakage impacts, more advanced types of models may have to be used.

As with the partial or focused models described in section 4.4.1, the systemic models also encompass both top-down economic models and bottom-up engineering models. These different models generally answer different questions. Bottom-up models estimate how financial costs and other outputs respond to changes in the infrastructure, technology, or efficiency landscape (Jaccard et al. 2003) while top-down models use economic data to estimate the broad economic impacts and costs of energy policies (Rivers and Jaccard 2005).

By linking together various parts of the economy, top-down models may give a more realistic picture of the economic effects of energy activities. However, these models are often criticized for taking technological change as a constant, naturally unfolding process, and thus ignoring the fact that future rates of technological advance may not be reflected in historical economic data (Grubb, Köhler, and Anderson 2002). More recently, hybrid models that combine these two types of models have been developed in an effort to address the deficiencies of the traditional models.

This section describes the top-down, bottom-up, and hybrid models that are most useful for policy makers considering or designing carbon taxes.

4.5.1 Econometric energy-economy models

Econometric models are top-down models that attempt to capture the behavior of the economy by identifying relationships between key variables that have been sustained over time. When an econometric model includes details of the energy sector behavior, such as how energy consumption responds to changes in prices or industrial output, the econometric model can be used to analyze the effectiveness of energy policies.

Best uses of econometric models:

- ✔ Capturing observed historical responses to changes in prices
- ✔ Estimating the level of government revenue from various carbon tax designs
- ✔ Estimating impacts of a carbon tax on labor, income, and related economic indicators
- ✔ Evaluating how a number of economic sectors could react to a carbon tax
- ✔ Evaluating the implications of narrow versus broad carbon taxes
- ✔ Estimating the effects of a carbon tax on economy-wide emissions

[27] See, for instance, Goulder and Williams, 2003.

4.5.1.1 How econometric studies work

Econometric models[28] use data on historical patterns of economy-wide responses to key exogenous variables (box 14) and policy variables to simulate aggregate sector and economy-wide responses to similar variables in the future. They rely upon statistical analysis to infer historical relations between changes in key economic factors (e.g., prices) and changes in the economy as a whole. The approach is based on the assumption that historical relations that have served as reliable predictors of economic relations in the past will continue to be useful predictors in the future.

Because econometric models are based on economy-wide responses, they make no assumptions about the behavior of individual actors. That means they do not assume any particular behavior on the part of consumers and producers. In contrast to other models that provide estimates of the costs of a carbon tax, econometric models provide estimates of the impacts on key aggregate measures such as changes in GDP, employment, consumption, and sectoral production.

Annex II provides a brief summary of econometric studies of carbon taxes.

4.5.1.2 Advantages of econometric models

Econometric models present certain advantages:

- **Open to discovery.** Econometric models, particularly the VAR type models (see footnote 27), start with relatively relaxed assumptions regarding which variables are included in a relationship. This allows for the discovery of relationships among variables that may not be obvious at the outset, sometimes referred to as letting the data speak. For example, while it might be expected that consumption of natural gas is linked to the price of natural gas and oil, econometric modeling allows less obvious statistical relationships to be found, for example, the finding that historical natural gas consumption patterns are statistically linked to per capita earnings or retirement payments.
- **No need to assume functional forms.** In CGE modeling (section 4.5.2), modelers must assume the form of the relation between certain variables at an aggregate level (e.g., an assumption regarding the form of the utility function for consumers). This is not generally required for econometric modeling.
- **Capture general equilibrium effects.** Econometric models allow modelers to incorporate general equilibrium effects in actual historical outcomes.
- **Flexible.** Modelers have quite a bit of freedom to include a range of variables that are of particular interest to policy makers.

4.5.1.3 Limitations of econometric models

The econometric energy-economy approach has important limitations:

- **Data requirements.** Econometric models tend to have very high historical data requirements, which may be prohibitive for some jurisdictions. Generally, econometric models of this type are based on annual data going back two or more decades. Generally, econometric models improve when based on large amount of data—for instance, across sectors, covering relatively long periods of time—but this means that getting worthwhile modeling results can require very large amounts of data.
- **Data mining.** The vast data sets to draw upon may necessitate "data mining," that is, testing large numbers of relationships until one is found that has a high correlation. Where these correlations are the result of chance and not of actual links (in other words, causation) between the two factors, these results may act as "red herrings" that prevent the identification of the real causal relationships.
- **Technology blind.** Top-down models are bound by past patterns, including technology choices. In a world of rapidly evolving technologies, this can be an important limitation on the insights this type of model can provide.

[28] Different varieties exist of econometric models, including the two primary types used in energy-economy applications—macroeconometric models and vector autoregressive (VAR) models. The former emphasize macroeconomic and financial variables, such as investment, savings, and money supply, while the latter emphasize key macroeconomic variables such as employment, earnings, and consumption.

Box 14. Technical Note: Exogenous and Endogenous Variables

Virtually all modeling applications use two types of variables: exogenous and endogenous variables. Exogenous variables are those that are specified outside the model, prior to running it, and so they remain fixed regardless of the results the model produces. For example, in many models, population levels and world energy prices are exogenous. While these may be very important variables for understanding the economic impacts of the carbon tax, they are generally beyond the scope of the model. Endogenous variables are those that are estimated by the model. For example, in a carbon tax model, the tax revenue and energy consumption would probably be endogenous variables.

4.5.2 Computable General Equilibrium (CGE) models

CGE models (also known as Applied General Equilibrium or AGE models) are useful for addressing a broad range of issues. They are based on microeconomic theory and are potentially data-intensive.

Best uses of CGE models:

- Comparing the performance of alternative policy instruments
- Estimating the level of government revenue from various carbon tax designs
- Estimating how total emissions would respond to a carbon tax
- Estimating the impacts on households of different income levels
- Evaluating how different economic sectors could react to a carbon tax
- Evaluating the implications of narrow versus broad carbon taxes
- Estimating changes in GDP caused by the carbon tax
- Estimating changes in energy prices caused by the carbon tax
- Evaluating cross-jurisdiction impacts
- Estimating the marginal cost of public funds and evaluating alternative uses of revenue.

4.5.2.1 How CGE models work

CGE models look at the economy as a system of interconnected actors and markets in which changes in one area can have impacts on many other areas. For example, a rise in the price of flour could cause a rise in the price of bread, which could in turn affect inflation, then wages, and next returns on investment.

This is the first great strength of CGE models: they are particularly suitable to capture feedback loops among sectors—the fact that activities in one part of the economy can have broader, economy-wide impacts.

The second strength of a CGE model stems from the fact that it is based on the microeconomic theory of consumer and producer behavior. This means it can capture the effects of the behavior of many types of actors (producers and consumers acting in any number of different sectors) to adjust in response to new "shocks" like a carbon tax.

The model comprises a system of equations that describe the relation among key variables (consumer purchases, industry production, resource use, etc.) and a database of historical data used to derive key parameters. In theory, all of the economic relationships in the model can be estimated based on past behaviors. In practice, only the key relations are estimated; the rest are based on judgement and theory.

The "mechanics" or "drivers" behind a CGE model is the assumption that consumers maximize utility, that producers maximize profits, and that the operation of markets will lead to supply (production) equaling demand (a condition known as "market clearing"). Consumers operate under budgets and producers compete for inputs (called "factors of production" or just "factors"). In this sense, CGE is based on the presumption of optimization: the consumers act to maximize their own welfare while the producers act to maximize profit.

One challenge with this approach, as with any top-down type of model, is that in practice these models tend to be highly aggregated and do not provide the level of detail required to examine specific effects. For example, the highly regarded Global Trade Analysis Project (GTAP) model, which covers 57 sectors, still aggregates the transportation and communications sectors. While particularly relevant to carbon tax modeling, many CGE models will aggregate energy demand in a way that masks differential effects across fuels or among specific manufacturing industries. They tend to miss sector-specific market structures and competitive responses.

Annex III provides a summary of results from several CGE models, indicating the range of impacts that has been estimated for carbon taxes implemented in different countries.

4.5.2.2 Advantages of CGE models

CGE models have several appealing attributes:

- **Theoretically rigorous.** By working from an initial specified set of relationships that capture the relations among major economic activities, modelers develop a rigorous, systematic model that depicts the feedback loops throughout the economy. This is consistent with a modeling philosophy that argues structure should be imposed on the data rather than allowing the data to determine the structure.
- **Estimations of welfare impacts.** CGE models work through welfare and profit-maximizing actors. Whereas econometric models can estimate the impact of a carbon tax on important economic variables such as national GDP, CGE models provide estimates of welfare impacts, measured in monetary units (e.g., euros or dollars).
- **Representation of consumer and producer behavior.** Because the model explicitly models consumption preferences and production processes, it is possible to identify how both consumers and producers respond to various changes in policy or other variables such as prices.

- **Estimations of distributional effects.** Some models disaggregate their representation of consumers to differentiate the behavior of different income classes. This can be critical, for example, to examining whether a carbon tax will be regressive in a particular setting. Microsimulations using household or firm-level data can assist in assessing these impacts.

- **Highly flexible.** CGE models are particularly well suited to analyze a range of policy initiatives (on tax, trade, pollution control, etc.), even when multiple initiatives are considered for simultaneous implementation.

- **Capture resource limits.** Because CGE models look at a closed system of relations, resource limits are built in—households are subject to budgets, the economy cannot consume more of a resource than it produces, and the like.

- **Tracking policy impacts.** Unlike the econometric modeling approach described in section 4.5.1, CGE models explicitly track the impacts of a policy from one actor to another. So the model shows not only the final impact, but also the series of relations through which the impact developed.

4.5.2.3 Limitations of CGE models

While CGE models are very powerful, they also have their limitations:

- **Challenging to build and subject to imprecisions.** Building a CGE model can be a challenging process that requires a great deal of skill. More specifically, the modeling requires identifying the key relations in the economy and choosing how to portray them. This can require a combination of theory, intuition, and guesswork. Even once key relations and their forms have been specified, modelers still have to identify the values of key parameters (e.g., the elasticity of demand for each good). Even a well-structured model produces results characterized by great uncertainty.

- **No statistical validation of the model.** CGE models are fundamentally theoretical. There is no way to validate or test CGE models against observed behavior. Indeed, their highly constrained structures can also force modelers to make assumptions that might be considered unrealistic (e.g., some CGE models impose structural assumptions that force all fuel price elasticities to unity, whereas most empirical evidence suggests these elasticities are much lower).

- **Aggregated sectors.** Because they attempt to represent the entire economy, CGE models tend to aggregate at a fairly high level. Particularly relevant to carbon tax modeling, CGE models tend to focus on the energy demand of entire countries, perhaps because of the challenge of obtaining the large amounts of data needed to support a disaggregated CGE model.

- **Unresponsive to technology changes.** Because the models impose assumptions regarding the form of the production process (referred to by economists as the "production function"), the estimated relations do not have high correlations with observed behavior. Like the econometric models, CGE models do not readily accommodate sudden changes in technology that are not consistent with historical trends.

- **Lack of transparency.** One criticism of CGE models is that because they are relatively complex, they provide fewer insights into the underlying factors that determine consumer and producer responses to carbon pricing. However, this shortcoming can be partly addressed by conducting a sensitivity analysis.

4.5.3 Energy system optimization models

In contrast to the econometric and CGE models, bottom-up energy system models are technology- rich, allowing modelers to examine the effect of technological adaptation and innovation in the face of new policies.

Best uses of energy system models:

- ✔ Analyzing potential technological adaptations in response to a carbon tax
- ✔ Analyzing potential changes in fuel use and GHG emissions motivated by a carbon tax
- ✔ Evaluating the effect of potential new technology developments (cost reductions) on emissions.

4.5.3.1 How energy system models work

Energy system models are depictions of physical systems that deliver energy services. As such, they include models of, for instance, electricity generation, process heat for industry, or motor fuel use for transport. Generally, the model assumes a given level of demand—including demand for energy production, energy conversion, and end-use technologies—and then seeks the most cost-effective combinations of technologies that can meet the given demand.

The TIMES-MARKAL model, for example, works from the assumption that energy systems are managed to supply energy services (e.g., residential heating) at the lowest possible cost. An array of technologies is available to supply each energy service, and the model is programmed to identify the lowest-cost configuration that meets specified energy demands. Assumptions about the availability and costs of various technologies over time can then be adjusted to test different potential scenarios.

4.5.3.2 Advantages of energy system models

Energy system models offer important advantages:

- **Explicit technological representation.** The top-down models represent technological change as either an autonomous process of improvement that is independent of policy and that will continue at the same pace as in the past (econometric models) or as changes in aggregated production processes (CGE models). As energy systems models involve highly detailed representations of technologies, modelers can build in very specific assumptions about future technological developments (e.g., electric vehicles will meet 25 percent of new vehicle demand by 2025).
- **Adjustment potentials.** Energy system models facilitate testing the energy sector's technical capacity to adjust to changes in relative energy prices and to examine the effect that this would have on costs and emissions. In the case of a new carbon tax, an energy system model would indicate which technologies would be added or expanded, which would be replaced, and how this would affect the mix of fossil fuels and renewable energy.
- **Response to a change in demand.** These models can also examine how energy systems would adjust to a change in the demand for energy services, such as a given rise in the industrial demand for electricity.

4.5.3.3 Limitations of energy system models

While these bottom-up models provide a great deal of insight into potential means and costs of adaptation in the energy system, they also have several limitations:

- **Adaptive behavior.** Where CGE and econometric models can capture adjustments to changes in prices or income, energy system models take demand as being independent of price. They generally do not take into account changes in consumer behavior (e.g., consuming less energy services when the price of fuel rises) or feedback loops in the economy (e.g., lower demand for energy services in response to lower economic growth).
- **Assumed technological optimization.** Energy system models are based on the assumption of cost minimization. However, consumers do not always optimize their energy consumption. Where econometric models can capture lagged or partial adoption of cost-effective technologies, bottom-up models generally assume complete adoption of the least-cost technology.
- **No connection to other sectors.** Bottom-up models do not take into account relations between energy and other sectors of the economy (Murphy, Rivers and Jaccard 2007).

4.5.4 Hybrid models

To take advantage of the relative strengths of both the top-down economic and bottom-up engineering approaches, researchers in recent years have concentrated on developing hybrid models that blend the two approaches. This has, at times, been an uneasy marriage but many of the initial challenges have been met. The primary disadvantages of this hybrid approach are that the models are complex, even more data-intensive than the other approaches, and not very transparent.

Best uses of hybrid models:

- ✔ Analyzing potential technological adaptations in response to a carbon tax
- ✔ Analyzing potential changes in fuel use and carbon dioxide emissions motivated by a carbon tax
- ✔ Evaluating the effect of potential new technology developments (cost reductions) on emissions.

4.5.4.1 How hybrid models work

Hybrid models generally have two components or modules—a top-down model of the economy (either an econometric or CGE model) and a bottom-up, energy system model.

While many variations on this approach exist, the models are generally linked by (i) energy prices and (ii) energy service demands. In a typical arrangement, the models start with a set of demands for various energy services. These demands, combined with fuel and technology prices, are run through the energy model, which in turn produces a set of costs or prices for the energy services. These are transferred to the economy model which, based on the estimated energy service prices, revises the demand estimates. This process is cycled through the two components until they converge on a set of prices and demands.

To examine the implications of policy changes, modelers can introduce a price change (e.g., through a carbon tax that raises the price of fossil fuels) or a constraint (e.g., a limit on carbon emissions associated with an ETS).

4.5.4.2 Advantages of hybrid models

The hybrid model combines the explicit technology depiction of the bottom-up models with the economic insights of the top-down models. It allows modelers to better anticipate how technological advances might affect the economy and how changes in the economy might shift the technology mixes in energy production and consumption.

4.5.4.3 Limitations of hybrid models

The primary limitation of the hybrid model is that it carries the data and modeling requirements of both types of

Table 15. Summary of Modeling Approaches and Their Characteristics

	PARTIAL/FOCUSED MODELS		GENERAL/SYSTEMIC MODELS			
	Partial Equilibrium	Engineering Cost	Econometric	Computable General Equilibrium	Energy System	Hybrid
Top- down vs. bottom-up	Top-down	Bottom-up	Top-down	Top-down	Bottom-up	Blended
Best uses	Sector-specific carbon tax modeling	Estimates of costs of abatement based on specific technologies	Estimates of impacts on macroeconomic indicators (e.g., GDP and employment)	Estimates of costs and their distribution	Evaluation of cost and potential for emission reductions	Evaluation of adaptation of energy system to changing economic conditions
Primary advantages	Simple; focused; inexpensive	Transparent; focused	Flexible; historically anchored	Theoretically anchored; estimates welfare impacts	Allows adaptation of technology	Portrays interaction of economic and technology adjustments

models—bottom-up and top-down. Moreover, it can be challenging to combine the outputs of the economic model (generally, energy quantity demanded by fuel type) with the input requirements of the energy model (energy service demands), just as it can be difficult to match the outputs of the energy model (total energy service costs) with the inputs of the economy model (generally, energy prices of each fuel type). From the perspective of a policy maker or carbon tax administrator, this could require assembling and maintaining a substantial modeling team with a wide range of skills in economic and technology modeling.

4.6 CHOOSING AMONG THE MODELING APPROACHES

As can be seen from the discussion above, a wide range of modeling approaches is available to support decision making on carbon taxes, each with their respective strengths and weaknesses. Table 15 provides a summary of the main options.

In choosing which model to use, it is important to bear in mind the following factors:

- **Analytical and financial resources.** Because some models can be data- and labor-intensive, they can also be very expensive. The impact of a carbon tax can be substantial and the cost of the modeling process may well be justified, but jurisdictions should plan to budget for that undertaking. At the same time, some of the approaches described above require very little resources.
- **Geography/economy specific.** Each model needs to be adapted to the specific economy, geography, and demographics of the jurisdiction that it is applied to. Even for existing models, this can be a data- and labor-intensive undertaking.
- **Time-intensive.** Advanced models can take a substantial time to develop—months or even years, in some cases. Policy makers should plan well ahead if they intend to commission a sophisticated modeling exercise.
- **Expected level of tax.** If the tax rate is expected to be quite low, advanced modeling is probably not necessary as the economic impacts will probably also be relatively low. Even if the potential tax is expected to be quite high but to fall within a narrow band, advanced analysis is still probably not required to compare the effects of different rates. Given the uncertainties inherent in complex economic models, these models might not be sensitive enough to meaningfully estimate the different impacts across these kinds of narrow ranges.
- **Data requirements.** The advanced models, especially of the top-down variety, can be very data-intensive. Policy makers should inquire whether the available data are of sufficient quality and scope to support a meaningful modeling exercise. Where a jurisdiction has extensive economic data—on tax behavior, energy markets, abatement opportunities, international trade, etc.—the outputs of more advanced modeling approaches will be of higher quality and therefore more informative. On the other hand, where a government has limited data, developing or running models will not necessarily generate meaningful insights into likely carbon tax impacts.

- **Level of disaggregation.** As policy makers consider initiating an advanced modeling project, they should clarify the type and level of disaggregation of results. For example, is it important to be able to distinguish among impacts on low-, middle- and high-income households? Between the mining sector and the building sector? Among impacts in different regions of the jurisdiction?

Given the lack of a single "best" model, jurisdictions might choose to create multiple models with the understanding that each can yield its own insights. For example, a simple analysis based on a partial equilibrium model, with its emphasis on how consumers and producers might respond to a range of prices and related factors, can provide insights into the economy's responsiveness to changes in carbon pricing. This could be supplemented with a richer model that accommodates a wider range of important factors, interactions, and impacts.

Additional guidance on evaluating and modeling options for GHG emission reduction policy is provided in the Partnership for Market Readiness (PMR) "Checklist on Establishing Post-2020 Emission Pathways." [29]

[29] See https://openknowledge.worldbank.org/bitstream/handle/10986/21877/EPEP_eBook.pdf.

Key Considerations

- Many types of models and analytical tools are available. They vary significantly in the approach they take, and each has its own strengths and limitations, thereby making it more or less suited to answering different kinds of questions.
- Where sufficient data and resources are available, it may be worthwhile conducting assessments with multiple types of models to take advantage of their different strengths.
- In choosing modeling approaches, jurisdictions should carefully consider which policy questions are most important to them—the ones primarily dealing with economic impacts or technological issues; the questions mainly addressing specific sectors/industries and technologies or system-wide impacts and adjustments; and the like.
- Models are seldom meant to be actual predictions of outcomes, but rather are intended to provide insight into the relative impacts of alternatives. They should therefore be used as part of, rather than as a substitute for, the decision-making process.
- In choosing among various modeling approaches, jurisdictions should consider the costs, amount of time to completion, and skill sets required.

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PART II

DESIGNING CARBON TAXES

5 DEFINING THE TAX BASE

At a Glance

The tax base of a carbon tax refers to the taxable products, activities, and persons that will be liable for making carbon tax payments. Defining the tax base is among the first and crucial decisions to be made in designing a carbon tax.

Carbon taxes are typically applied to the production, import, or sale of fuels, or to emissions from specific processes, such as those from electricity generation, industrial processes, or waste disposal. Deciding whether to apply the carbon tax to fuels, to processes, or to a combination of both will often be the first step in determining the tax base, since a range of other design choices depend on the broad approach that is taken on this question.

The following are the key decisions policy makers will have to make in determining the tax base:

1. **Which emissions should be taxed?** The first step in defining the base is determining which emissions to target. Taxing the production, import, and sale of fossil fuels is the most straightforward way to tax carbon emissions, since most jurisdictions can "piggyback" the new tax on existing systems and will only need limited additional tax administration capacities. Also targeting other emissions such as those derived from electricity generation, industrial processes, and waste disposal may require more administration, but may also allow for targeting a larger amount of emissions. All other factors being equal, broader taxes can bring important benefits in terms of maximizing emission reductions and economic efficiency, and governments can choose to phase in sectors over time as administrative capacities are developed. Factors influencing the scope chosen include the policy objectives of the tax, the emissions profile of the jurisdiction, the broader political climate, the energy and tax policy landscape, and the structure of key sectors and government capacities for tax administration and Measuring, Reporting and Verification (MRV).

2. **At which point in the supply chain should the tax be placed?** The tax can be applied to a range of different actors along the supply chain, from importers and producers (upstream) to distributors or electricity generators (midstream) and consumers (downstream). Where the tax is applied to fuels, it is common to place the obligation upstream or midstream, since this is the approach followed under existing excise tax rules. For taxes applied to direct emissions, several options may exist. Decisions will have to take into account which actors are likely to respond to the price signal of the tax by reducing emissions, as well as the implications for MRV and administration of the tax at different points in the supply chain.

3. **Which actors will be legally responsible for tax payment?** Even at a specific point in the supply chain, various legal entities may be involved in trading fuels or producing emissions. The government must therefore determine which of these entities will be legally responsible for paying the tax. In the case of taxes applied to fuels, this will generally be determined by existing rules on the payment of excise taxes. In the case of taxes on emissions from a facility, such as from power plants, landfills, or factories, the tax will usually target the entity with ownership or operational control of that facility. Other decisions include whether to require self-identification of entities or government-led identification, and how to apportion emissions in highly interconnected facilities.

4. **Will thresholds be applied below which no tax is payable?** A threshold is a minimum level of activity that will trigger responsibility for paying the tax, usually adopted to reduce the costs of reporting and administration. The use of thresholds is common in the case of carbon taxes applied directly to emissions (i.e., not to fuel) and where there is a relatively high number of actors and a significant variety in their size and capabilities.

5.1 INTRODUCTION

One of the first steps in designing a carbon tax is determining the scope of the tax: which gases, which economic sectors, and which activities will the tax cover? A closely related issue is determining the point of taxation and possible thresholds of application, which determine the actors that will be targeted within a given sector. Jurisdictions also take different approaches to deciding which legal entity will be liable for tax payment. Decisions on these issues have important implications not only for the coverage of the tax, but also for issues such as administrative burden and political acceptability.

Determining the tax base requires making decisions on all of these issues. Though they are distinct decisions, they are closely related and, when defining the tax base, it is important to carefully consider the overall design—how the four key decisions come together—in determining each one. For instance, taxes targeting fossil fuels carry significantly different considerations in terms of point of regulation and thresholds than taxes targeting non-fossil fuel-based emissions.

This chapter sets out the key issues that need to be considered in determining the scope of taxation, and in each case reviews the broad options available and the implications of different decisions. It then goes on to discuss a key, crosscutting issue that influences all of these decisions, namely MRV and administration.

5.2 SCOPE OF TAXATION

Determining the scope of taxation involves a number of decisions. In the first place, policy makers must decide which emissions they want to target, including which specific sectors, activities and gases. Next, the point in the supply chain at which emissions are taxed needs to be determined. Closely related to this, is determining the legal entity that will be held liable, and finally governments should consider whether they will exclude emissions below a certain threshold from the tax. These decisions are elaborated in the following sections.

5.2.1 Choosing which emissions to tax

A first step in defining the scope of the carbon tax is deciding which emissions it will cover. The definition of coverage can be based on the targeted sectors or subsectors, the types of greenhouse gases (GHGs), or the types of fuels. Though the approaches taken by jurisdictions vary (table 11), two broad starting points can be identified based on existing experience.

- **Targeting fuels.** Many jurisdictions have applied carbon taxes to one or more specific fuels, primarily oil, gas and coal, and their derivative products. For example, British Columbia taxes 23 fuels, including oil, gas and coal, while Mexico taxes coal and petroleum, and India taxes only coal. In these cases, the tax is typically applied upstream or midstream (section 5.2.2)—to fuel producers, importers, or distributers—and the tax is calculated based on the carbon content of the fuels, not on the actual emissions occurring downstream.

  It is nonetheless also possible to tax fuel used for specific purposes, such as the United Kingdom does, where the Carbon Price Support is applied to fuel used by electricity generators. Some jurisdictions have, in addition, included exceptions when applying this approach. Japan, for example, applies its carbon tax to the use of gas, oil, and coal, but excludes their use in the petrochemical, agriculture, and fisheries sectors, among others. EU jurisdictions exempt the use of fuel by entities covered under the European Union Emissions Trading System (EU ETS). Jurisdictions may also choose to exempt fuels used by companies operating Carbon Capture and Sequestration (CCS) technology, as the United Kingdom does.

  Targeting specific fuels can be attractive from an administrative perspective and support cost-effectiveness, as fuels are typically already subject to excise taxes, and carbon tax administration can "piggyback" on the systems already in place for these by applying differentiated carbon tax rates for fuels based on their carbon content. Such taxes are broadly considered "indirect taxes," since eventually the taxpayer (i.e., the consumer) pays the tax indirectly through the purchase of fuel, rather than directly to the tax authorities.

- **Targeting direct emissions.** Other jurisdictions have structured the tax so as to target specific sectors or economic activities, such as in the case of Chile, where the tax targets emissions from large boilers and turbines (regardless of the type of fuel they use). A variation on this approach is to focus on certain processes and types of emissions, as is done in South Africa, where the tax targets fossil fuel combustion, industrial processes, product use, and fugitive emissions.

  This approach allows for coverage of activities beyond fossil fuel combustion and, therefore, also of GHGs other than CO_2, and can align with the emissions sectors used under United Nations Framework Convention on Climate Change (UNFCCC) reporting (as, e.g., in Australia's former system and in South Africa). In this way, jurisdictions may be able to ensure broader coverage, especially where a large part of their emissions are not fuel-based. On the other hand, in the case of taxes based on actual emissions rather than on the carbon content of fuels, jurisdictions may need to establish new systems for MRV of emissions (table 16).

Table 16. Sectoral Scope and Point of Regulation across Existing and Planned Carbon Taxes

ISSUE	FOSSIL FUEL TYPES COVERED	COVERAGE OF NON-FOSSIL FUELS	COVERAGE (%) GHGs	SECTORS COVERED	MAJOR EXEMPTIONS	POINT OF APPLICATION
Australia	All	Yes	60	Electricity generation, industry, waste, fugitive emissions	Legacy landfills	Midstream and downstream
British Columbia	All	No	70	Purchase and sale of fuels	Interjurisdictional commercial marine, interjurisdictional commercial aviation, exports, and colored gasoline and diesel used solely for farm purposes	Tax is payable downstream but collected upstream
Chile	All	No	38	Boilers and turbines with capacity equal to or greater than 50 MW	None	Midstream on power producers
Denmark	All	No	45	Purchase and sale of fossil fuels	EU ETS sectors	Upstream on producers and importers, and midstream on distributors
France	All	No	35	Purchase and sale of fossil fuels for heating and transport	EU ETS sectors, freight transport, public transport, taxi operators, farmers, air transport, fishing, navigation, and shipping	Upstream on producers and importers, and midstream on distributors
India	Coal	No	46	Coal extraction	Coal mined by local tribes in the state of Meghalaya	Upstream at mine mouth
Ireland	All	No	33	Purchase and sale of fossil fuels	EU ETS sectors, agriculture, heavy oil and LPG (partial), high-efficiency CHP (partial), and fuel used in agriculture (income tax relief)	Upstream on producers and importers, and midstream on distributors
Japan	All	No	70	Purchase and sale of fossil fuels	Coal for electricity generation in Okinawa; volatile oil for petrochemicals; domestic oil asphalt; oils for agriculture, forestry, and fisheries; fuels for domestic flights; rail transportation; domestic cargo and passengers ships; and imported coal used for home production of caustic soda and salt	Upstream at mine mouth

Mexico	Coal, oil	No	40	Purchase and sale of fossil fuels	Gas is not subject to the tax	Upstream on producers and importers
Norway	Oil, gas	Yes	60	Purchase and sale of fossil fuels Hydrofluoro-carbons (HFCs) and Perfluoro-carbons (PFCs)	Partial exemption for EU ETS sectors, except for offshore petroleum production; international air and maritime transport; fishing in distant waters; herring meal industry; fishing meal industry; and commercial greenhouses	Upstream on oil and gas companies in continental shelf and HFC/PFC importers; midstream on fuel suppliers
Portugal	All	No	26	Purchase and sale of fossil fuels	EU ETS sectors	Midstream
South Africa	All	Yes	75	All sectors involving fossil fuel combustion, industrial processes, product use, and fugitive emissions	International flights and ships	Upstream (fuel refiners), midstream (electricity generators), and downstream (industrial facilities)
Sweden	All	No	42	Purchase and sale of fossil fuels for heating and transport	Full exemptions for EU ETS installations; Partial exemption for heating fuels used in industry agriculture (up to 2017), and diesel for agricultural vehicles and vehicles used in mining	Upstream on producers and importers, and midstream on distributors
Switzer-land	All	No	35	Electricity and heat production	Energy-intensive companies subject to international competition, large companies that are covered by the Swiss ETS, SMEs that make emission reduction commitments	Upstream on producers and importers, and midstream on distributors
United Kingdom	All	No	25	Electricity generation covered by EU ETS	Use in small generating stations, use in small CHP plants, use in CHP plants that use electricity on-site, use in stand-by generators, use of coal slurry, use in Northern Ireland, use in generating stations with CCS	Midstream (electricity generators)

Note: For a full list of sources used for this information, please refer to the appendix.

5.2.1.1 Considerations for determining scope

In practice, the definition of the coverage across jurisdictions reflects a wide range of combinations of the approaches described above. This is because determining the right coverage is very context-specific and depends on a number of national circumstances (chapter 3). Some of the most important factors to consider are the following:

- **Policy objectives.** Jurisdictions will want to align the carbon tax with their climate and economic policy objectives (section 3.3). Where the carbon tax is primarily an emission reduction policy, jurisdictions tend to focus on sectors that are high emitters and are not yet targeted by other climate policies. In jurisdictions without a carbon pricing system in place, a broader carbon tax will typically provide greater opportunities for emission reductions and can offer important economic efficiency gains compared with narrower carbon taxes. Jurisdictions keen to raise revenue may focus on sectors with high emissions and where higher taxes are not expected to lead to reduced economic activity.

- **Political considerations.** Closely related to policy goals are political considerations, which will invariably play a role both in determining scope and in exempting particular fuels and industries. For example, Ireland decided to effectively exempt agricultural fuel use because of a preexisting commitment by the government not to introduce new taxes for the agricultural sector, and Mexico exempted natural gas in the context of a national policy push to expand natural gas use. These considerations may arise from interest group pressure, or be motivated by fairness concerns, especially regarding the impact that the carbon tax can have on low-income households. While the political and equity constraints are legitimate concerns for policy makers, they can to some extent be addressed through the use of the carbon tax revenues (chapter 8). In all cases, it is important that the process of deciding which sectors will be covered be undertaken transparently and the reasons behind those decisions be effectively communicated.

- **Emissions profile.** Mapping GHG emissions in the jurisdiction is central to determining where the highest emissions take place, and therefore where the tax is likely to have the biggest impact on emission reductions and carbon tax revenues. This process is described further in section 3.3.2

- **Emission reduction opportunities.** Where a key goal is to reduce emissions, the jurisdiction may choose not to apply the tax where few opportunities exist for emission reductions, with a view to maximizing environmental integrity and cost-effectiveness. Though one of the advantages of a carbon tax is that it can trigger innovation and discovery of unknown abatement options, it is nonetheless important for policy makers to assess the general potential for emission reductions. Where this does not exist, the tax will only act as a revenue-raising measure.

- **Responsiveness to price signals.** Related to the previous point, whether a sector or an actor is responsive to the price signal provided by the tax is key to whether the tax will incentivize emission reductions. This question can be settled using tools such as marginal abatement cost curves, elasticities of demand for fossil fuels, and energy systems models and econometric models. These approaches are discussed in detail in chapter 4.

- **Policy mix.** The presence of existing emission mitigation policies is an important consideration in determining sectoral scope. To the extent possible, jurisdictions should seek to align the carbon tax with other existing and planned policies. As discussed in chapter 2, some policies can be complementary to a carbon tax (e.g., those encouraging research and development), while others may overlap (e.g., an ETS). Other policies might counteract the price signal of the carbon tax, such as subsidies for taxed activities (e.g., for fossil fuels or agriculture). In some sectors, a carbon tax might even run contrary to other low-emissions policies. For example, where a government is seeking to incentivize switching from biomass to gas in buildings and the biomass market is mostly local and informal (and hence difficult to tax), placing a carbon tax on the use of gas in buildings could be counterproductive.

- **MRV and administration capacity.** The availability of appropriate capacities for monitoring emissions and collecting taxes in certain sectors or from certain fuels can greatly facilitate the implementation of a carbon tax. Where these are not available, the level of new capacity needed for different sectors will often be an important consideration in determining the scope of the tax. This aspect is discussed in detail in section 5.3. Where capacity is stronger in some areas than in others, as is often the case, jurisdictions can consider beginning with coverage of some emissions (e.g., those from fuels already subject to excise tax) and then gradually expand the scope as capacity is developed.

- **Legal authority.** Some governments may be restricted in their ability to tax certain products, activities, or persons. This is most obviously the case in countries with federal or similar systems, where the federal and state/province governments will each have a distinct set of taxing powers. This is discussed in more detail in section 2.3.3.

5.2.1.2 Approaches taken in practice

While approaches taken by jurisdictions will be context-specific, existing experience suggests four broad approaches may be identified, as shown in box 15.

5.2.2 Determining the point of regulation

The generation of emissions from a given sector or activity typically involves a range of actors operating at different points in the supply chain. In addition to determining which sectors or activities will be subject to the tax, jurisdictions must therefore also determine which of the various groups of entities involved will be responsible for paying the carbon tax. Though the number of points in the supply chain will differ across sectors, they can broadly be categorized by three distinct points of taxation (see figure 13 for an illustration of where the tax can be applied in the case of fossil fuels).

- **Upstream:** Upstream carbon taxes are applied to fuels at the point where the product associated with the emissions enters the economy. In the case of fuels, this would include a coal mine mouth, a gas wellhead, or a port for imported fuels. In the case of agricultural emissions, the farm would be the upstream point, while in the case of emissions from landfills, upstream would refer to the point of waste disposal.
- **Midstream:** A midstream carbon tax refers to a tax that is applied somewhere between the point where the product enters the economy and the point of consumption. This is often at the point of processing: for example, where the oil is refined (refineries); where the fuel is converted to electricity (power plant); or when meat is processed (processing plant). A tax applied to intermediate distributors of a product (e.g., fuel distributors) can also be considered a midstream tax.
- **Downstream:** A downstream carbon tax is applied at the point of consumption, whether by consumers, businesses, or industry. Examples include a tax applied to the use of energy by businesses, fuel use by a transport company, or a tax on the consumption of meat. In the waste sector, the inverse is true, since waste is generated upstream by consumers and flows downstream to a landfill or incinerator operators.

In determining the point of regulation, two factors are cucial: (i) targeting actors responsive to the price signal; and (ii) administrative and MRV considerations. Both of these factors are important to ensuring the efficiency and cost-effectiveness, as well as the environmental integrity of the carbon tax. As MRV and administrative considerations are closely interlinked with the determination of the optimum scope and the issues of thresholds and level of reporting obligation, they are considered separately as a crosscutting issue in section 5.3.

Box 15. Comparison of Approaches to Implementing a Carbon Tax

The expansive approach

The expansive approach, taken by British Columbia, South Africa, and previously Australia, for example, seeks to apply the carbon tax as broadly as is feasible within the limitations presented by factors such as MRV and administration, using the tax as their "flagship" emission abatement policy. This approach is often economically the most efficient, as it reduces the overall costs of emission reductions in the economy by creating more opportunities for cost-effective abatement. It can also reduce opportunities for intrasectoral leakage and is attractive to jurisdictions with ambitious emission reduction or revenue-raising targets.

The complementary approach

Under the complementary approach, jurisdictions apply the tax to sectors and activities not covered under other emission reduction policies. It has been broadly applied by EU jurisdictions such as France, Ireland, Denmark, and Portugal, to cover the use of fossil fuels not covered by the EU ETS. Mexico has also adopted this approach, having decided to apply an ETS to large emissions sources in industry and electricity generation. In many cases, an upstream or midstream tax is applied to sectors with dispersed emissions sources such as in the transport sector and buildings, where EU ETS coverage was deemed too costly or impractical.

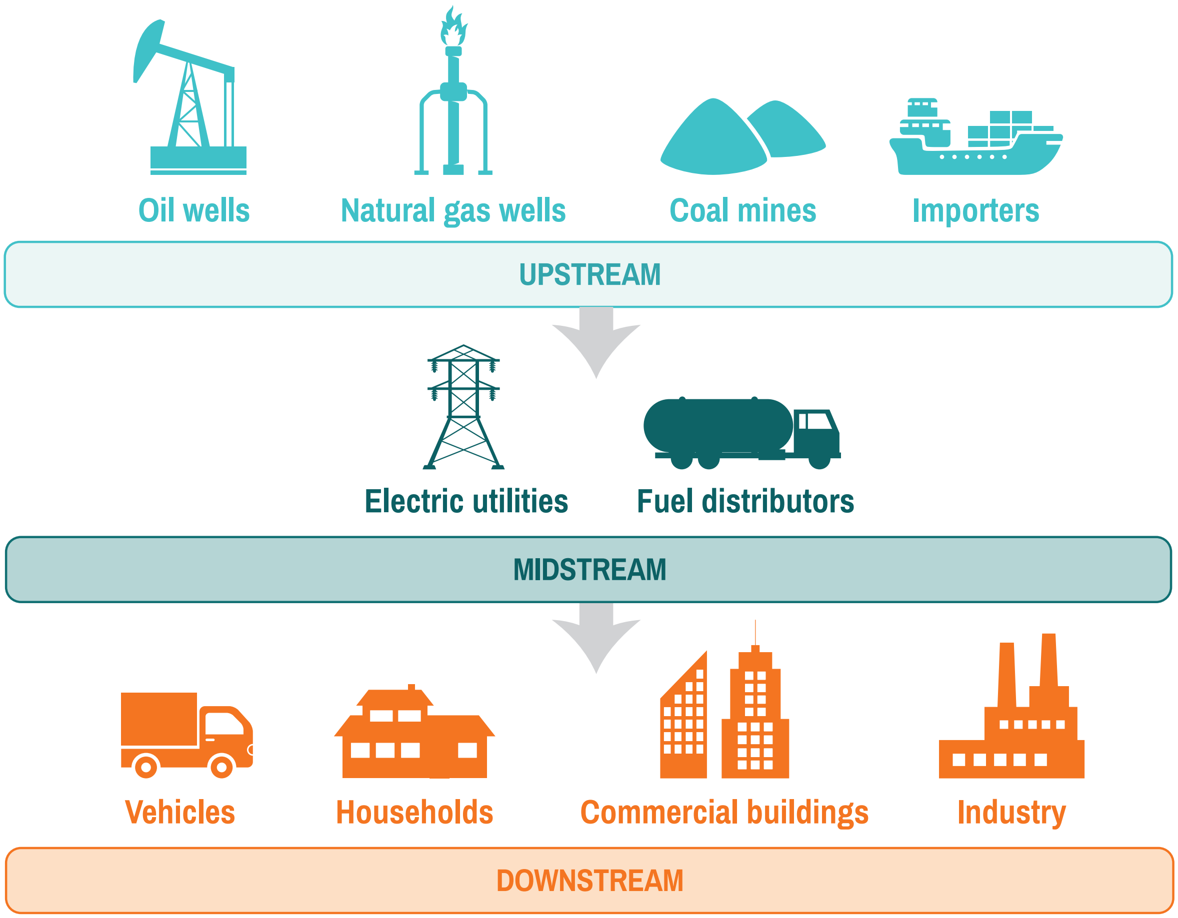
The "top up" approach

In contrast to the complementary approach, some jurisdictions may seek to enhance the incentive an existing policy provides by applying the tax to sectors already covered. This is the approach taken by the United Kingdom, which responded to the weak price signal provided by the EU ETS by applying a Carbon Price Floor to "top up" the EU ETS price paid by electricity generators so long as that price remains below the floor.

The policy-specific approach

Some jurisdictions have used a carbon tax to address specific policy objectives by applying it to just one or a few activities. India, for example, has applied the tax only to coal in order to raise funds for clean energy development. In Mexico, the carbon tax targeting oil and coal was adopted in the context of national policies to boost natural gas production.

Figure 13. General Categorization of Potential Points of Regulation for Fossil Fuels



Source: Ramseur and Parker 2009.

5.2.2.1 Identifying actors responsive to price signals

In order for a carbon tax to be effective in reducing emissions, it is essential that the increased costs fall on entities whose behavior affects the level of emissions. If actors who do not have decision-making power or whose decisions are not responsive to price signals are targeted, the increased cost will add to their financial burden, but their emissions will not change.

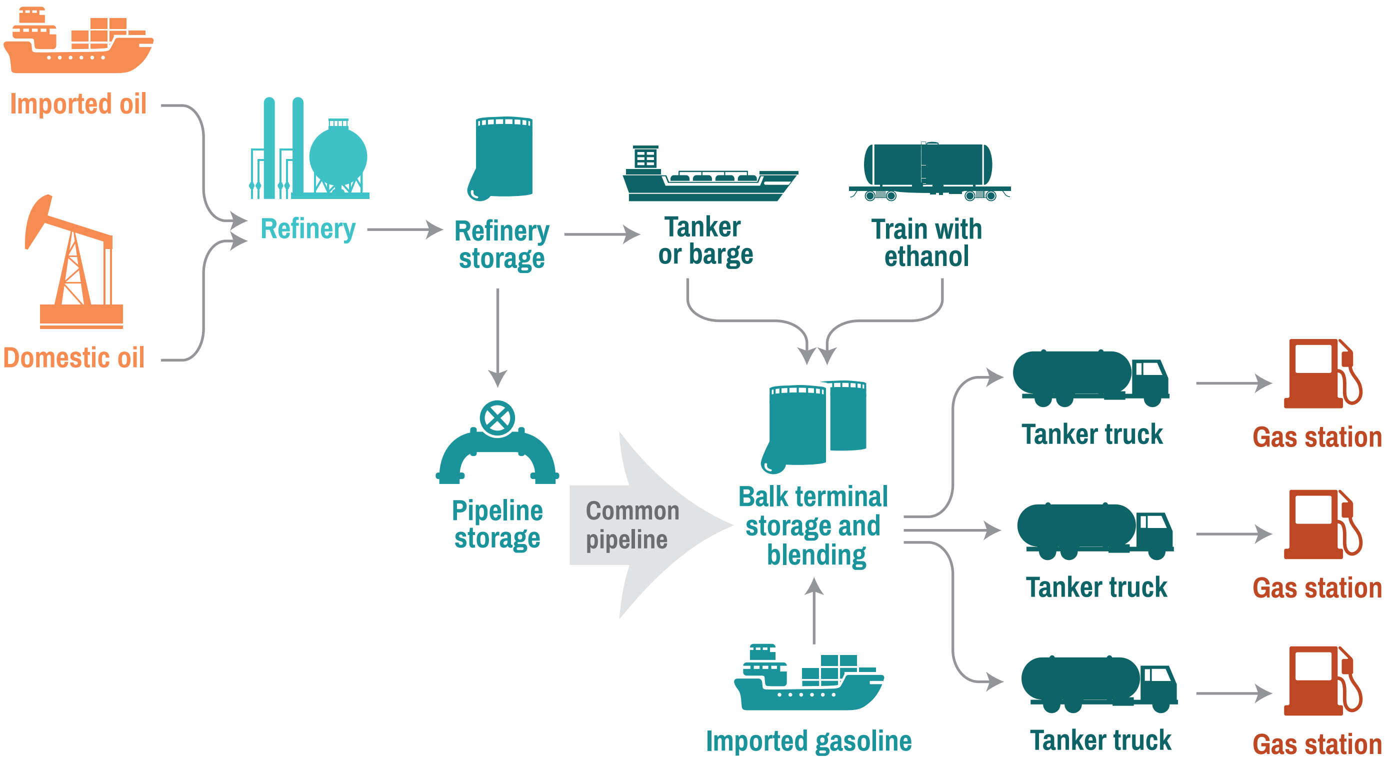
In determining which actors' behavior is relevant for emission reductions, it is important to first consider which emissions are being targeted and the point in the supply chain where emissions actually occur. Take, for instance, the different considerations that apply to taxing the gasoline supply chain depicted in figure 14, which depend on the emissions that are targeted.

- To reduce methane emissions from oil extraction, the tax would be applied most effectively if applied to extraction companies who have the option to either introduce practices that reduce methane leakage or capture the methane and convert it to energy. Another practical advantage of this strategy is that this is the point where emissions can actually be measured. Applying a tax to refinery operators or consumers would not be effective, since these actors have limited influence over decisions taken at the point of extraction. It is also worth noting that the costs of a tax applied at this point may be passed through to distributors and consumers, and thereby induce lower use of gasoline, further reducing emissions.

- To reduce CO_2 emissions from oil refining, the actor with the most scope for emission reductions is the refinery operator, who can substitute energy sources or increase efficiency. Here again, increased costs may be passed on to consumers, but consumers will have little direct influence over decisions made in the refining process, so taxing the consumers directly is unlikely to induce emission-reducing behavior.

- To reduce CO_2 emissions from fossil fuel use by consumers, policy makers have more flexibility. While the emissions themselves occur upon use by the consumer, the amount of carbon contained in the fuel at any stage in the process is roughly equal to the amount that is eventually released in emissions, for example, from vehicles or home heating. Thus, a tax could be applied upstream (at the extraction well or refinery),

Figure 14. The Gasoline (Petrol) Supply Chain



Source: United States Energy Information Administration, 2013.

midstream (at the distributor level), or downstream (at the consumer level), and in principle equally influence the decisions concerning the eventual emissions from that fuel. As long as the price is passed down (section 5.2.2.2), the consumers' behavior is thus directly targeted.

The gasoline supply chain example illustrates how the effect of a carbon tax on the behavior of different actors is strongly influenced by where the tax is placed. In general, upstream taxes have the ability to flow downstream and affect multiple actors in the supply chain, while the reverse is less true. The specific influence on actor behavior does, however, vary considerably per sector and type of emission. Table 17 illustrates how this actor-influence consideration applies across the most important sectors and emission sources.

5.2.2.2 Cost pass-through and visibility

Despite the general rule that price signals flow downward as they are passed on to consumers, it is important to consider whether there are any barriers that prevent the price signal provided by the carbon tax from reaching the consumer. In a well-functioning market with flat supply curves, a tax that is levied upstream or midstream will be passed through to the consumer. In these cases, an upstream or midstream tax will be just as effective in reaching the consumer as a downstream tax. On the other hand, where markets do not function perfectly, the price signal of an upstream or midstream tax may not reach the consumer. For example, if regulated electricity generators are not able to pass along increases in their costs to consumers, consumers will not be incentivized to adjust their behavior. In this case, unless the barriers that make it impossible for the generators to pass on their costs can be removed, a downstream tax will be more likely to change consumer behavior, while a midstream or upstream tax won't affect consumers but should still incentivize a lower-carbon energy mix. An alternative option, adopted by the South Korea ETS and several Chinese ETS pilots, is to cover electricity generators for the emissions they generate and to cover large downstream electricity users such as industrial facilities for the emissions associated with the electricity they consume in addition to any emissions they directly generate.

An additional important consideration is the "visibility" of the carbon price to the relevant actors. Even where the full cost of the carbon tax can be passed through to actors further down the supply chain, the actual effects of this cost may depend on how visible the carbon price is to the actors in question; in other words, whether the cost is faced directly, per ton of CO_2e emitted, or indirectly, as increased fuel prices. Organizational and behavioral factors suggest that where actors can directly see the price being paid per ton of CO_2e, they are more conscious of the effects of their emissions on costs and more likely to actively try to find ways to reduce their emissions. This also enhances the transparency of the tax. Though applying the carbon price directly to the actor whose behavior is targeted is the most obvious way of doing this, other options exist. For instance, in Switzerland, the carbon levy is applied to importers and distributors; nonetheless, the portion of the final price paid by consumers is clearly indicated on the invoice for the energy delivered, making the signal visible. Requiring or encouraging electricity and fuel distributors to highlight the carbon price portion on invoices or through other means can therefore help to increase the visibility of the tax.

5.2.3 Determining the legal entity responsible for tax payment

A further important design decision concerns who is legally responsible for paying the carbon tax. The answer will depend on the scope and point of regulation of the tax—in particular, whether the tax is placed on fuels or direct emissions—and the legal system of the jurisdiction.

Table 17. Actor-Influence Considerations across Emission Sources

SECTOR OR PRODUCT	MAIN SOURCES OF EMISSIONS	CONSIDERATIONS
Fossil fuels	Fugitive emissions from extraction	Fugitive emissions occur at extraction, and mitigation options are largely in the hands of extraction companies. Placing a tax anywhere other than at the point of extraction is likely to have a limited effect on these emissions.
	Energy use in refining	Emissions from energy use in refining occur at the refinery if energy is produced on-site, or else at the electricity generator. Refiners can mitigate emissions by switching to lower-carbon forms of energy or increasing efficiency. A tax placed upstream at extraction, midstream at generation level, or downstream on energy use at the refinery would in principle have equal effects on the refiner's decisions.
	Electricity generation	Emissions from electricity generation occur at the point of combustion at the power plant. Mitigation options are, however, available at the plant itself—through use of low-carbon energy sources and more efficient generation—and at the consumer level, since consumers can switch to providers that use lower-carbon forms of energy. A tax levied upstream or at the generator level will, assuming cost pass-through, reach all these actors, whereas a tax levied downstream at the consumer level will influence consumer behavior but not incentivize the generator to make generation more efficient.
	Transport and heating	Emissions in transport and heating occur downstream when the fuel is used by consumers. Assuming the cost of the tax can be passed through, a tax applied at any point in the supply chain will incentivize consumers to reduce fuel use or switch to lower-carbon fuel sources.
Industrial processes	Industrial processes	Emissions from industrial processes are released where the process occurs. The operators of industrial facilities have mitigation options. Carbon taxes in this sector will therefore almost invariably be levied at this point.
Waste	Landfills and incinerators	In the case of both landfills and incinerators, emissions occur on-site and mitigation options include those available on-site and the overall reduction of waste. Landfill/incinerator operators have the capacity to adopt on-site mitigation options, while waste producers (among others, households) can reduce the amount of waste they produce. Where a tax is applied to operators, they may have an incentive for on-site mitigation, but they can also pass through the costs to the waste producers. Where the tax is applied to waste producers, there is an incentive to reduce emissions, but not for on-site mitigation.

Agriculture and forestry	Land-use change	Land-use change emissions occur when farmers convert forest or peat land to agricultural land. A carbon tax that seeks to address this issue would arguably best be levied on farmers, based on the emissions deriving from such conversion. A tax levied further downstream on consumers, based on their consumption of products associated with deforestation, may be effective if accompanied by strong labelling schemes that can distinguish products grown on converted land, but this approach is hindered by multiple technical challenges.
	Forest management	Similar to land-use change, a tax on carbon emissions from forest management (e.g., on average reductions in forest carbon stock) would also best be placed at the level of the land/forest owner or manager. This could incentivize forest owners to implement sustainable management practices or increase stock. However, such an approach would need to grapple with the high cost of monitoring emissions from forest management at the site level. An alternative option is to place a tax on the sale of raw timber, with exemptions or reductions for timber from certified sustainable forests.
	Enteric fermentation and manure	Emissions from enteric fermentation and manure from ruminant animals occur on the farm. Some jurisdictions will have options for reducing the level of emissions from these sources through improved farming practices, and in these cases the switch to cleaner practices can be incentivized by taxing the farmer, being the one who can decide to introduce these practices. In other jurisdictions, limited technical mitigation opportunities may exist, and so any mitigation would stem from reduced consumption. In this case, applying the tax at the farm or consumer level will have the same effect, provided the costs can be passed through.
	Fertilizer use	Emissions from fertilizer use are generated through the overuse of fertilizer on crops, and subsequent nitrous-oxide emissions from the soil into the atmosphere. Mitigation options include reducing fertilizer use to better match plant needs, which requires a significant knowledge investment that could be incentivized by a price signal. As the key actor here is the farmer, a carbon price applied at the farm, or further upstream at the fertilizer manufacturer, can be effective. A tax applied further downstream, at the consumer level, would have limited effects.
	Fuel use	The same considerations apply here as in the case of transport emissions, above.

5.2.3.1 Tax on fuels

Taxes placed on fuels will in most cases follow the existing rules applicable to the payment of excise taxes. In many jurisdictions, the entity responsible for excise taxes is either a wholesaler or distributor, or a large fuel user. For example, in the EU, fuels that are not taxed at the time of production or import may be stored and distributed by registered taxpayers in registered "tax warehouses." The moment the fuel is either sold to a non-taxpayer such as a gasoline station or business consumer, or is used for own consumption by a registered taxpayer (usually in the case of large consumers), the tax must be paid. Registered taxpayers pay a security to cover potential losses in storage or transport. This provides a secure and tested system for ensuring that tax obligations are met. Carbon taxes on fuels in EU countries (i.e., in Denmark, France, Finland, Ireland, Portugal, and Sweden) are levied in this way.

An alternative approach in the case of taxes on fuels is to levy the tax on consumers, but enlist fuel distributors as "tax collectors" to reduce the administrative burden. This is the approach taken in British Columbia, where fuel vendors must be appointed as tax collectors by the revenue authorities and are then responsible for charging tax to purchasers upon sale. Vendors are required to pay a security to the government equivalent to the full amount of the tax payable by the consumer.

5.2.3.2 Tax on direct emissions

For taxes levied on direct emissions such as emissions from electricity generation, industrial processes, or waste disposal, obligations will generally be levied on the legal entity producing those emissions. Two main approaches exist to define the legal entity:

- **Ownership.** The entity that owns the emitting facility is liable for tax payment. In the case of multiple owners, the obligation may be placed on the entity with the controlling share, or divided between the entities based on their equity.
- **Control approach.** The entity that exercises operational control over the emitting facility (i.e., has the authority to adopt and implement operational policies for the facility) is liable for tax payment.

Often the choice of approach will depend on existing regulatory structures. To date, the control approach has been more commonly used, for instance in the carbon tax in South Africa and the former Australian tax. In cases where a single company owns or controls multiple emitting facilities covered by the carbon tax, emissions from each facility may be reported separately (section 9.3) but will nonetheless be subject to a single tax liability for all emissions.

In either case, jurisdictions may decide to require self-identification of tax liable entities, as in Australia and South Africa, or to provide the government with the authority to identify tax liable entities, as in Chile. In the former case, emitting entities are responsible for checking whether the tax applies to them and, if so, taking the necessary steps to report and pay tax obligations. The introduction of emissions monitoring systems covering all liable entities prior to the carbon tax in both Australia and South Africa has meant that in these cases it is relatively straightforward for entities to self-identify. In Chile, by contrast, not all liable entities were subject to prior emissions monitoring obligations or registered in a single database, resulting in the need for a detailed assessment of the entities that are covered by the tax.

In cases where multiple companies interact within one installation, the attribution of emissions to particular companies can be difficult. These problems may be particularly pronounced, for example, in highly integrated chemical production sites, where several companies or subsidiaries may run numerous production processes and where—in order to improve the overall efficiency of production—different processes may constantly exchange energy (in the form of waste heat, waste gas, cooling capacity, power, etc.) or products (e.g., hydrogen, pre-products, and hydrocarbons). In these cases, the government will need to adopt clear accounting rules that clarify which entities are responsible for accounting for which emissions.

5.2.4 Thresholds

A threshold is a minimum level of activity that will trigger responsibility for paying the tax—that is, a minimum level of emissions per entity for the taxation to apply. A threshold can reduce the costs of reporting and administration. The use of thresholds is common in the case of carbon taxes applied directly to emissions (i.e., not to fuel upstream) and where a carbon tax is applied at a point where the number of actors is relatively high and their size and capabilities vary significantly. For instance, in Australia's Carbon Pricing Scheme, emissions were taxed at the point where they were released into the atmosphere, for instance at electricity generators, industrial facilities, and landfill operators. In this case, the government opted for a 25,000 tCO_2e threshold in order not to burden smaller facilities with reporting obligations. Similarly, Chile decided to apply its midstream tax on electricity generators—only to plants with a minimum capacity of 50 MW.

Key considerations for choosing the threshold include:[30]

- **Proportion of emissions attributable to small emitters.** If there are many small sources of emissions in sectors covered by the carbon tax, a relatively low threshold may be needed to ensure that, in totality, a significant proportion of emissions is covered.
- **Cost of reporting in relation to tax amount.** With respect to actors responsible for relatively low emissions, the expected costs of reporting can be excessive relative to the actual taxes owed. The effective tax on the emitter can be understood to equal the tax levied plus the reporting costs. Policy makers may decide not to apply the tax in cases where reporting costs would equal or exceed actual tax payable.
- **Capabilities of firms and regulators.** If small firms have limited financial and human capacity to administer the carbon tax or if the ability of the regulator to oversee smaller firms is limited, a more generous (higher) threshold may be preferred.
- **Likelihood of intrasectoral leakage.** A threshold above which entities are subject to a carbon price and below which they are not, may distort competition between the two groups. It may thus be worthwhile to try to find a threshold that is consistent with the competitive dynamics within the sector.
- **Possibility of market distortions as a result of thresholds.** A threshold for entity inclusion can create an incentive to break up existing production facilities into smaller units in order to bring each unit's emissions below that threshold to avoid compliance obligations. Similarly, firms just below the threshold may choose to stay there, purposely curbing their growth.

[30] Adapted from PMR and ICAP, 2016.

By contrast, jurisdictions that apply their tax to fuels at the level of distribution have typically not applied thresholds. Applying a tax to fuels normally does not require direct measurement of emissions and is relatively easy to apply; moreover, it is in any case often built upon existing excise taxes, thereby making thresholds less necessary. Applying thresholds in these cases would also create distortions by encouraging consumers to purchase from smaller wholesalers.

5.3 CROSSCUTTING CONSIDERATION – ADMINISTRATION AND MRV

A key consideration informing decisions on scope, point of regulation, thresholds, and the determination of liable entities will be the implications of different decisions for the ability to accurately measure, report and verify emissions. Closely related considerations are the costs and effort associated with MRV and with tax administration more broadly. While in an ideal world a carbon tax would be applied to the sectors and at the point where it is most environmentally effective, in practice the decision will be influenced by the administrative burden involved in applying the price at different points in the supply chain. Table 18 summarizes the main MRV and administration considerations that will influence each of the decisions considered in this chapter.

MRV and administration considerations differ depending on whether jurisdictions focus the carbon tax on targeting fossil fuels or other sectors and activities. The considerations for each case are laid out in the following sections.

5.3.1 Targeting fossil fuels

By far, most jurisdictions that have adopted a carbon tax to date have focused it on the use of fossil fuels. This has the distinct advantage of allowing the carbon tax to "piggyback" on existing customs and excise taxes. In these cases, MRV tends to be relatively simple and straightforward. Most jurisdictions will already have systems in place for monitoring quantities of fuel produced, imported, and sold for the purpose of levying excise taxes, and so carbon emissions are easily calculated by applying an emissions factor, based on the carbon content of the fuel. While this will require some additional capacities and processes, in most cases these will be relatively limited.

The point of regulation will in most cases be placed upstream, at the point of production or import, or mid-stream, at the point of distribution. Downstream users may also be targeted in the case of large facilities that are registered taxpayers. In both of these cases the number of entities is relatively small, thereby making the oversight of transactions more manageable.

Table 18. MRV and Administration Factors Influencing Carbon Tax Design

DECISION	MRV AND ADMINISTRATION FACTORS
Sectors and activities	Availability of preexisting systems for monitoring inputs, outputs, or transactions in different sectors Availability of preexisting systems for tax collection and administration in different sectors Availability of (general and country-specific) emissions factors in different sectors Number of participants in different sectors
Point of regulation	Number of emitters at different points of taxation Availability of preexisting systems for MRV or tax administration at different points of taxation Technical capacity of emitters at different levels to undertake monitoring and reporting of emissions or proxies (e.g., fuel use)
Level of reporting obligation	Access of different entities to data required for measuring and reporting emissions (entity with operation control most likely to have best access)
Thresholds	Share of small emitters in covered sectors Question whether emitters need to directly measure and report their emissions for tax reporting purposes (as opposed to only reporting on fuel use/sales) Technical capacities of smaller emitters in covered sectors

Where jurisdictions provide exemptions for certain fuels or fuel uses, they will need to have systems in place for applying these. Where an exemption is applied to a given fuel that can be physically distinguished from other fuels, it will usually be possible to simply exclude that fuel from payment obligations. Where fuels are physically similar but sold through different channels, governments can use markers such as dyes to distinguish taxable and non-taxable fuels. In the cases where only certain uses of a taxed fuel are exempted, governments will usually provide for eligible persons to claim tax rebates, requiring evidence that the fuel was used for the stated purpose. In the case of exemptions for entities that are using Carbon Capture and Sequestration (CCS) technology or capturing and destroying industrial gases, the government may require that entities claiming such rebates provide proof for the amount of fuel used in facilities with CCS technology, and for the amount of carbon captured.

5.3.2 Targeting direct emissions

A limited number of carbon taxes have targeted direct emissions, most notably in Australia, Chile and South Africa. In these cases, the following considerations inform decision making.

5.3.2.1 Ability to accurately monitor emissions

In some sectors, reliable proxies and emissions factors exist, as is often the case in the electricity sector, for example. Emissions from industrial processes, such as CO_2 emissions from cement production and emissions from landfills and waste treatment, are slightly harder to monitor because of the greater number of inputs involved and the higher variability in emissions levels across installations. Agriculture emissions can be even more difficult, and estimation of emissions from land-use change can be especially challenging. The ability and level of efforts needed to monitor emissions meaningfully in a given sector can therefore be a key consideration in determining sectoral scope.

MRV standards and processes may also be less or more developed at different points in the supply chain. For instance, the measurement of emissions from electricity production by generators typically follows well-established procedures in most jurisdictions; benefits from the use of established grid emissions factors; and builds upon existing reporting of energy use by generators, thereby easily allowing a tax to be applied midstream in that sector. By contrast, downstream energy users may not always have such sophisticated energy monitoring systems in place.

5.3.2.2 Number of entities involved

Applying the carbon tax in sectors where there is a point in the supply chain with relatively few actors will be more feasible since it limits the number of entities that have to measure and report emissions and pay the tax. Applying the tax at a point in the supply chain where the number of actors is lower and more easily identifiable will imply a lower administrative burden for regulators, while targeting the larger actors avoids putting disproportionate burdens on smaller entities.

Typically, the largest number of actors is found downstream, while the numbers are far more limited upstream and midstream. For example, electricity generation plants typically serve very large numbers of consumers. This is one of the key factors explaining why carbon taxes in the electricity sector are applied midstream (e.g., Chile). By contrast, the agricultural sector may not have any point in the supply chain with relatively few actors, unless either production or distribution is concentrated in a small number of large companies.

5.3.2.3 Capacity of entities to monitor and report emissions

In sectors where reporting entities have developed technical capacities to monitor inputs (e.g., fuel) or outputs (e.g., electricity), these capacities can often be adapted to measure and report emissions. This will often be the case of large industrial installations, which will typically already have systems in place for monitoring inputs, outputs, and other emissions proxies. Where reporting entities have little or no experience with MRV, this can present a challenge.

The inclusion of landfills under Australia's former Carbon Pricing Mechanism highlights this difference. Many large landfills were commercially run, already charged based on volume, and had relatively detailed data on waste composition. Many also already had gas capture facilities that were generating emission reduction credits under various government schemes. These entities therefore had few problems adapting to the carbon tax. By contrast, other landfills were operated by local authorities, most of whom did not have these capacities, and so several of these needed to quickly build capacity for measurement and reporting.

5.3.2.4 Availability of preexisting systems

Many jurisdictions are already operating or developing MRV systems for national accounting, which often requires certain entities to measure and report their emissions to national authorities. Where this is the case, applying the carbon tax to these entities avoids the need for new systems to be established. South Africa, for example, intends to link MRV under the carbon tax to the South African National Atmospheric Emissions Inventory System (NAEIS). In other cases, an MRV system can be built upon systems for reporting on factors that can be used as emissions proxies. For example, in Chile, data on energy use, provided by electricity generators and industry, will feed into the MRV system.

Key Considerations

- Having a clear picture of the different policy objectives the government seeks to achieve with the carbon tax, while also understanding their relationships and being able to prioritize between them, is important for guiding the decision-making process. Cross-government consultation can help to align and prioritize objectives across different ministries.
- To understand how the carbon tax can contribute to mitigation of GHG emissions, it helps to have a clear idea of the specific emission reduction or abatement target of the jurisdiction and the role of the carbon tax in meeting those targets. It is equally important to understand the emissions profile of the jurisdiction and the value chains in key sectors.
- As a carbon tax works through the price signal, it is important to understand the economic characteristics of key sectors and the level of responsiveness to price signals.
- Having a clear picture of the government's capacities in key areas is important for informing a number of design decisions. Where this is unclear, capacity assessments can help inform decision making.
- Gaining a thorough understanding of the political landscape early on, including the main areas of support for and resistance to a carbon tax, is crucial for informing both the substantive design of the tax and the design of an effective stakeholder engagement process.
- The FASTER Principles for Successful Carbon Pricing can serve as a valuable tool to guide the evaluation of potential carbon tax design options.

FURTHER READING

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6 DETERMINING THE TAX RATE

At a Glance

Setting the tax rate is among the most important decisions in adopting a carbon tax. Jurisdictions have adopted a wide range of tax rates—ranging from US$3 per ton of carbon dioxide equivalent (tCO_2e) in Japan to US$132 per tCO_2e in Sweden—and jurisdictions will need to consider their policy goals as well as their economic, technological, social, and political context in determining the rate that works best for them.

The design of the carbon tax rate involves two major decisions: (i) choosing the basis for setting the original carbon tax rate; and (ii) deciding the process for the development of the tax rate.

Policy makers have generally adopted one of four basic approaches to setting the carbon tax rate:

- **The social cost of carbon (SCC) approach.** This approach matches the carbon tax rate to estimates of the social costs of greenhouse gas (GHG) emissions. It is one of the most economically efficient approaches. While the wide range of estimates of the SCC makes this approach challenging, there is a strong argument for not permitting the effective carbon tax rate to fall below the minimum estimates of the SCC, as lower rates would go against the polluter pays principle.
- **The abatement target approach.** This approach involves choosing a carbon tax rate that is expected to result in abatement levels consistent with the jurisdiction's emission reduction objectives; it is thus a good choice for jurisdictions seeking to meet specific mitigation targets.
- **The revenue target approach.** This approach is designed to generate a particular amount of revenue through the application of the carbon tax. It is particularly useful for jurisdictions motivated by the need for additional public funds.
- **The benchmarking approach.** This approach links the tax rate to carbon prices in other jurisdictions, particularly neighboring countries, trading partners, and competitors.

Each of these bases for the carbon tax rate will often merely be a starting point, as it will in practice often be adjusted during the political process leading up to the adoption. Policy makers will also need to identify whether and how to adjust taxes in the years following initial implementation. The main options in this context are the following:

- **Static carbon tax rate.** The carbon tax remains constant over time, and it may or may not be tied to the rate of inflation.
- **Gradually increasing carbon tax rate.** A carbon tax trajectory is defined in the original carbon tax design, generally starting from a relatively low level, and rising over time.
- **Matching the SCC.** The tax rate is stipulated to change with adjustments in the official estimates of the SCC.
- **Adjustment formula.** During the design process, policy makers stipulate a formula to be used for periodically adjusting the tax rate.
- **Periodic review.** Experts, government administrators, and other stakeholders undertake reviews and recommend adjustments in tax rates.
- **Ad hoc political approach.** Adjustments to the tax rate are handled by legislators or policy makers on an occasional or periodic basis.

Many jurisdictions have adopted a combination of these approaches for adjusting the carbon tax rate. In choosing among approaches, policy makers must balance the need for predictable tax rates with the need to adjust the tax rate in response to performance, impacts, and a range of external factors. It is also often desirable to set clear objectives (for setting the initial tax rate) and clear rules (for adjusting the tax rate) in order to mitigate the risks associated with policy changes for investments in low-carbon technologies and practices.

Determining the Tax Rate

6.1 INTRODUCTION

Perhaps the most important element of carbon tax design is determining the tax rate. The tax rate chosen, coupled with the decision on the coverage of the tax, will ultimately determine the amount of emissions abatement achieved, the revenue raised, and the economic impact of the tax.

Two key decisions typically underlie these tax rates:

- Identifying the basis or principle to be used in setting the tax rate
- Determining whether and how the tax rate will vary over time after its initial implementation.

These key decisions can be approached in different ways, and the approach chosen will largely depend on the underlying objectives of the jurisdiction. In practice, jurisdictions have adopted a wide range of tax rates (table 19). For example, Chile, India, Japan, and Portugal have all adopted tax rates between the equivalent of US$3 and US$6 per tCO_2e. By contrast, Switzerland has adopted a tax rate equivalent to US$87/$tCO_2e$, while Sweden's rate is US$132/$tCO_2e$.

Table 19. Examples of Carbon Tax Rates

GOVERNMENT	PRICE IN 2015 USD PER TON OF CO_2e[a]
British Columbia	22
Chile	5
Denmark	31
Finland	48–83
France	24
Iceland	10
India	6
Ireland	28
Japan	3
Mexico	1–4
Norway	4–69
Portugal	5
South Africa	8.50[b]
Sweden	132[c]
Switzerland	87
United Kingdom	16

Note: a. The carbon tax rates shown represent the tax rate in force in 2015, expressed in 2015 U.S. dollars, at the then prevailing exchange rates. For more details, see the cases of carbon tax case studies in the technical appendix to this report.

b. This rate is the "headline" rate for the South Africa carbon tax. In the first phase of the tax (from its implementation up to 2020), liable entities are allocated tax-free allowances of 60–95 percent, meaning that the effective tax rate paid by liable entities will be significantly lower than the headline rate.

c. Sweden currently still applies a lower tax rate to industry. However, as from 2018, the industry rate will rise to the same level as the general rate, and for that reason only the general rate is shown here.

This chapter will consider the options and considerations related to both these major decisions. Section 6.2 discusses four main approaches to setting the tax rate, and their respective uses and implications. Section 6.3 goes on to discuss approaches to defining the dynamics of the rate, that is, how it will develop over time.

6.2 BASIS FOR THE CARBON TAX RATE

As discussed in chapter 3, as governments design carbon tax systems, it is important to clearly define the goals to be pursued with the tax. This is particularly relevant to the tax rate decided on, since the rate can potentially be designed to achieve certain policy objectives, such as reaching a given level of emission abatement or revenue. There are several strategies for setting the carbon tax rate, and the best approach will depend in large part on the government's policy objectives.

This section will review four basic approaches to setting the tax rate:

- The social cost of carbon (SCC) approach
- The abatement target approach
- The revenue target approach
- The benchmarking approach.

6.2.1 The social cost of carbon (SCC) approach

The SCC approach involves reducing emissions to a level that is consistent with the economically efficient use of resources, thereby balancing the costs and benefits of GHG emission abatement.

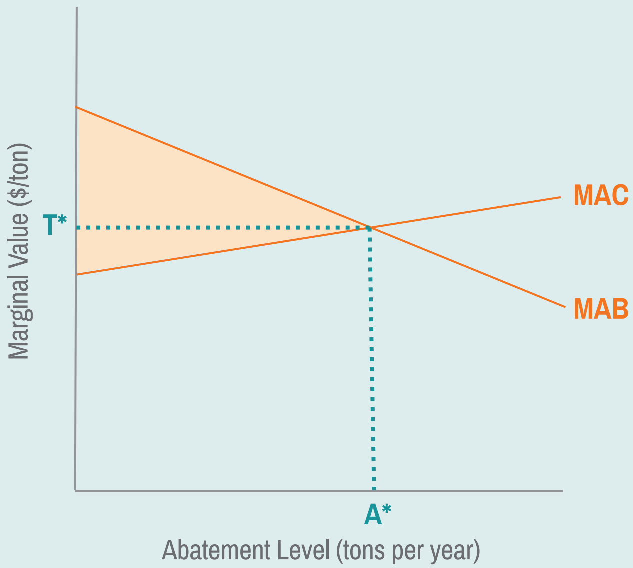
In its broadest sense, the SCC refers to the global damages caused by emitting one additional ton of CO_2e (i.e., in theory, the last ton emitted). Reducing emissions avoids these costs and results in marginal abatement benefits (MAB), depicted in figure 15 (box 16). Based on this approach, a jurisdiction promoting global economic efficiency would set the carbon tax equal to the SCC.

The SCC is based on estimates of the relationship between GHG emissions, climate change, and the (estimated) damages related to climate change. SCC estimates depend upon a large number of factors, including assumptions about the level of emissions and atmospheric concentrations of GHGs, estimates of the type and extent of damages, the

Box 16. Technical Note: Setting a Carbon Tax at the Social Cost of Carbon (SCC)

Conceptually, the SCC approach is simple. Policy makers set the carbon tax rate at the level where the marginal abatement cost (MAC) equals exactly the marginal abatement benefit (MAB), shown as T* in the figure. At this point, the cost of an additional ton of abatement equals the value of the abatement. When the tax rate equals T*, emitters will abate up to point A*, where the tax is just equal to their costs of additional abatement. If they abated more (that is, beyond A*), the cost of abatement would exceed the cost of the tax payment. The shaded area in figure 15 represents the total gain in value to society. Note that if the MAB curve is flat, it is optimal to set the tax, T*, equal to that (constant) MAB value.

Figure 15. Setting the Carbon Tax Rate through the SCC Approach



Note: MAC = Marginal Abatement Cost; MAB = Marginal Abatement Benefit.

valuation of those damages, and the applied discount rate[31] (lower discount rates result in a higher SCC).

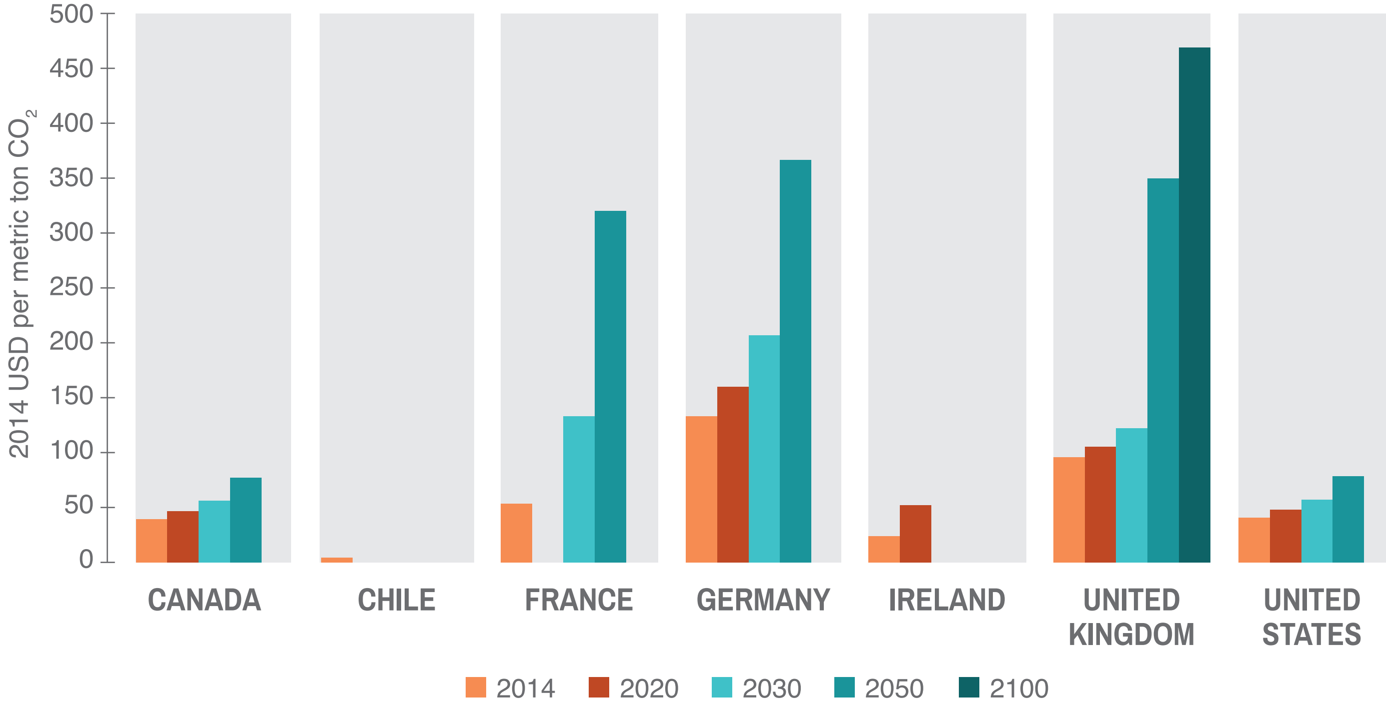
Although climate change impacts are often the primary consideration in setting the SCC, jurisdictions implementing carbon taxes to promote economic efficiency may expect additional benefits to be derived from abatement. By adjusting the MAB curve (and the implied SCC) to take into account additional benefits associated with the emission reductions and shifts in fossil fuel use, these jurisdictions may achieve a fuller representation of benefits. Relevant benefits include:

- **Health benefits**, such as decreased incidence of disease thanks to reductions in correlated pollutants, including sulfur dioxide and particulate matter from electricity generation. For example, an analysis of recent carbon dioxide regulations in the United States indicated that the health benefits from PM2.5 emission reductions were larger than the benefits associated with the SCC;
- **Better land and soil quality**, in particular through a range of activities in agriculture and forests;
- **Enhanced energy security**, thanks to a lower dependence on imported fuels;
- **Improved transportation system**, thanks to reductions in the degree of traffic congestion, the number of accidents, and the amount of pollutants from transportation systems. (These externalities may, however, already be addressed through other measures such as congestion taxes and fuel excises.)

Several governments have calculated the SCC and used it as an input for their policy-making processes based on cost-benefit analyses (though not necessarily for the purpose of setting a carbon tax rate). Because estimates of SCC have

[31] The discount rate refers to the rate at which future costs and benefits are discounted relative to current costs and benefits. Generally, benefits that occur in the future are valued less than similarly sized current benefits. In valuing future costs or benefits, the higher the discount rate and the further in the future the costs or benefits occur, the lower they are valued. Because the negative impacts of a current ton of carbon emissions occur over a long time horizon, often decades, they have to be discounted compared to their value if they occurred today; and the higher the discount rate, the lower the value of the damages associated with the emissions and hence the lower the SCC.

Figure 16. SCC Values Used in Ex Ante Cost-Benefit Analyses of Public Policies



Source: Smith & Braathen 2015.

Note: All amounts shown represent U.S. dollars.

varied so widely, governments have used a broad range of values in their policy process (figure 16). For instance, while the United States and Canada have estimated that the 2014 SCC is about US$40 per ton, several European jurisdictions have used much higher valuations—even more than US$130 per ton in the case of Germany. The differences among these estimates stem in part from differences in the models used: the physical impacts considered, the valuation of damages, and the discount rates applied. Substantial differences in SCC estimates can also arise depending on whether the SCC takes into account only damages within a jurisdiction or global damages.

While these estimates have been developed for use in cost-benefit analyses of public policies, the same calculation principles would apply if a jurisdiction were to set its carbon tax rate at the SCC.

The broad range of estimates associated with the SCC can prove challenging for jurisdictions that want to base their carbon tax on the SCC. For example, in setting its carbon tax rate, Chile had originally intended to use the SCC as its standard. However, given the lack of consensus on the value of the SCC, the government concluded this approach was not feasible in the short term and used international carbon prices as a proxy instead. Given that current international carbon prices are the product of market forces and an array of global political factors, this decision shifted the tax design process from using the SCC approach to, in fact, using a benchmarking approach (section 6.3.4).

As illustrated in figure 15 (box 16), the SCC also varies over time, which is related to the expectation that the damages from an additional ton of emissions will rise in the future because of, at least in part, increasing concentrations of GHGs in the atmosphere. The SCC should generally also take into account the time lag between emissions being released into the atmosphere and the climate damage occurring. This delayed effect means that a carbon tax with the primary objective of promoting efficiency would also have to rise in the future to match the expected trajectory of the SCC.

6.2.2 The abatement target approach

Carbon taxes can be an effective tool to reduce emissions. For example, a rough estimate of the mitigation effects of the carbon taxes in Norway suggests that emissions would have been more than 6 to 7 million tons CO_2e higher in 2010 than they were with the tax in place (Norwegian Ministry of Climate and Environment, 2014).

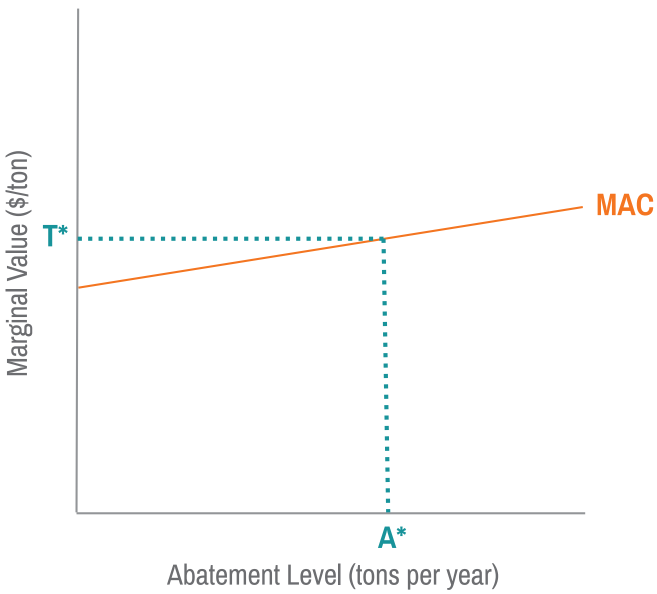
In cases where the primary goal of the carbon tax is to meet a specific emission reduction target—for example, targets set out in Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change (UNFCCC), or in national laws and policies—governments can decide to set the carbon tax rate at the level that is expected to enable the required abatement target to be achieved. Even where jurisdictions are concerned about long-term goals or are considering global-level targets, they will translate those to domestic targets for purposes of policy formulation.

Conceptually, the abatement target approach is similar to the one described in section 6.1.1, except that in this case the government is working toward a specific abatement level rather than calculating the cost and benefit of different potential levels of abatement. This distinction can be understood by revisiting the marginal abatement cost curves (MACCs) introduced in figure 15 (box 16). In the SCC approach, the policy starts by setting the tax, T*, equal to the SCC at the intersection of the MAC and MAB curves. The expected emission reduction is then determined by how entities respond to the tax. Under the abatement target approach, on the other hand, the reduction target pursued is known, and the MACC can be used to set the tax T* (without need for the MAB), as illustrated in figure 17.

Jurisdictions that use MACCs can determine the carbon tax for achieving a given level of reduction by identifying the T* (tax rate) that corresponds to A* (targeted level of abatement) on the MAC curve (figure 17). Two related assumptions are implicit in this approach. Where there is uncertainty about the estimated MAC, as is generally the case, there will also be uncertainty about the reduction level that will result from a specific tax rate. Secondly, it is assumed that liable entities will respond to the price stimulation of T* by adopting all abatement technologies and practices that have a lower cost than T* per tCO_2e. If there is "stickiness" in the system—that is, liable entities are not perfectly efficient in their response to the carbon tax price signal—the level of abatement can fall short of the expected level.

For example, to estimate the costs of GHG emission abatement, a jurisdiction might develop MACCs for household energy conservation, forest carbon sequestration, or renewable energy options. Generally, MACCs apply to one activity or to a subset of abatement activities. They can, however, easily be combined to give a more complete picture of options, as explained in chapter 4.

Figure 17. Setting the Carbon Tax Rate through the Abatement Target Approach



The shape and level of the aggregate MAC will be determined by many factors, including the coverage of the carbon tax relative to the country's emissions (chapter 5) and the existence of complementary policies (chapter 2). Note that the MAC may be lower in contexts where the government has instituted other policies to complement the carbon tax, such as public information programs, and technological development and diffusion programs.

While the MAC approach is relatively simple to apply, because it focuses on technologies and practices from a bottom-up perspective, it can miss important interactions among abatement alternatives as well as economic adjustments by producers and consumers. As described in chapter 4, more advanced modeling options are available that take into account observed economic behavior and energy system interactions. When these models are run with an imposed constraint, for example, "annual emissions cannot exceed X," the model calculates an implicit marginal cost of carbon abatement (often referred to as a shadow price). That marginal cost provides an estimate of the carbon tax that will induce the prescribed limit on emissions.

Australia is an example of a country that has used the abatement target approach. The Australian Treasury conducted extensive modeling to examine the relationship between carbon tax levels and abatement outcomes. That exercise examined the costs of meeting Australia's emission targets and derived the marginal cost associated with those targets. It also examined the emission reductions effect of carbon taxes initially set at US$20.34 and US$30.51, and allowed to rise over time. Although the final carbon tax of US$20.39 was determined through political negotiation, the results of these modeling exercises provided important input for the negotiations.

6.2.3 The revenue target approach

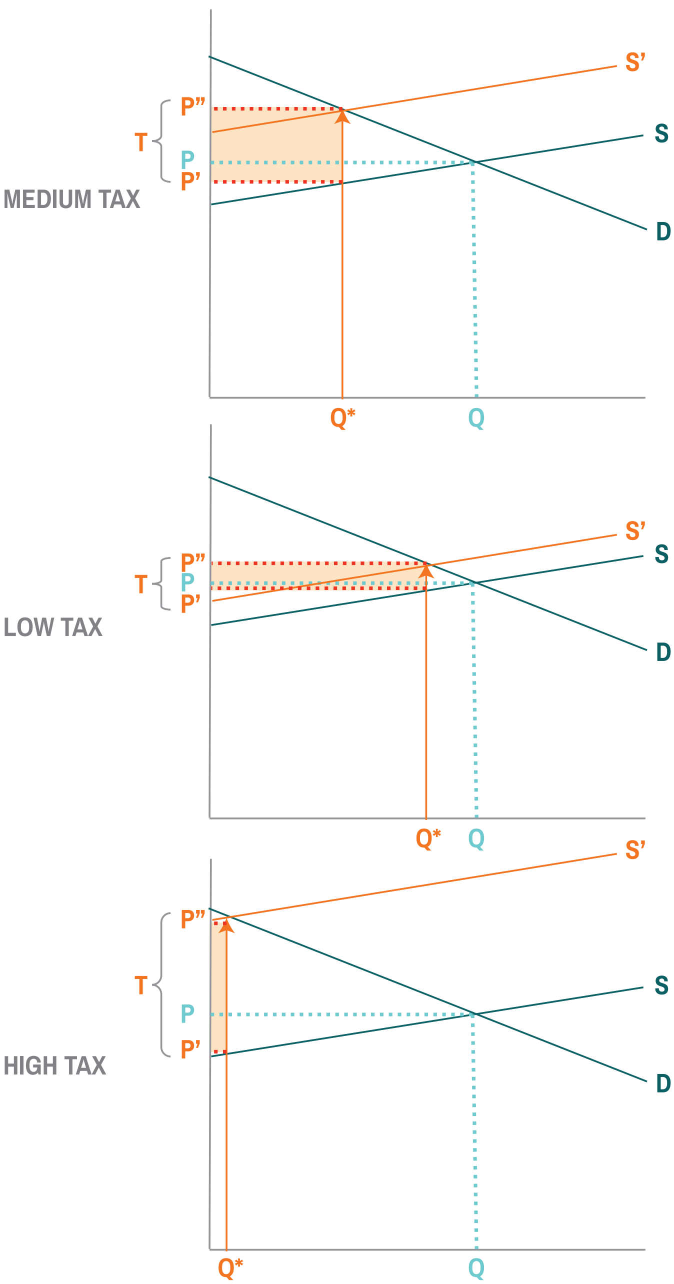
In some cases jurisdictions adopt carbon taxes primarily aimed at raising revenue. For example, in Chile, one of the main driving forces behind the carbon tax was the policy commitment to raise funding for education reforms.

In cases where the jurisdiction is driven primarily by raising revenue through the carbon tax, the tax rate can be set so that it generates a specific level of revenue, though within the constraints dictated by supply and demand.

When the government introduces a tax on a commodity, it essentially drives a wedge between the supply and demand curves. In the diagrams of figure 18, this effect is depicted as shifting the cost of production up, moving the supply curve from S to S'. Before the introduction of the tax, the supply and demand curves, S and D, intersect at a point corresponding to the market price (P) and quantity (Q). With the new, higher supply curve, S', the new point of intersection is P" and Q'. The tax revenue is, therefore, the product of the tax rate, T, and the new (lower) quantity, Q', that is, T × Q'.

Figure 18 also illustrates how the tax revenue (the shaded areas in each diagram) changes with different tax levels. Given an initial "medium" tax (upper graph), a certain revenue may be expected. It might be possible to increase that revenue by increasing the tax, but only up to a certain point. The center and lower graphs illustrate that either very low or very high taxes, respectively, can lead to lower tax revenues.

Figure 18. Setting the Carbon Tax Rate through the Revenue Target Approach



Note: D = Demand; P = Price; Q = Quantity; S = Supply; T = Tax.

The size of the shaded area corresponds to the tax revenue associated with each tax level (medium, low, and high, respectively).

In fact, there is an intermediate tax level between the two extremes that will maximize the revenue. Policy makers who seek to maximize revenues from a commodity can use these simple models to estimate the revenue-maximizing tax rate by identifying the point where the additional tax revenue from an increase in the tax is just offset by the loss in tax revenue from a decrease in the quantity that clears the market. This will correspond to the point where the shaded areas in the diagrams are the largest.

For carbon pricing, revenue maximization is a bit more complicated because the carbon tax is often translated from a price on carbon to a tax on fossil fuels. As each fuel has a different carbon content and a different supply and demand function, a tax that maximizes revenue from one fuel will not necessarily maximize revenue from another fuel. If a jurisdiction seeks to maximize revenue in this case, it could apply different carbon taxes to each fuel, although this approach is inconsistent with reducing emissions as efficiently as possible.

As described in the previous chapters, governments that seek to both reduce GHG emissions and raise revenue could encounter a tension between the two goals. At the outset, adding a small tax will simultaneously increase revenue and decrease emissions. However, as the tax rises, it will eventually reach a point where the carbon tax revenue hits a ceiling. Any additional increases in the carbon tax will enhance GHG emission abatement but decrease total revenue.

6.2.4 The benchmarking approach

Benchmarking provides one of the simplest and lowest-cost approaches to examining options for setting the carbon tax rate. Benchmarking involves simply examining what other, similarly situated jurisdictions—and international competitors—have done in terms of the overall tax design they adopted, and particularly the tax rate they chose. To identify jurisdictions appropriate for carbon tax design benchmarking, the following factors may be considered:

- **Similar demographics.** Demographics (including population size and density, education level, and employment type) can be a critical consideration in designing the carbon tax.
- **Similar economies/politics.** Because both political and economic circumstances are critical factors in setting the carbon tax and determining its ultimate impacts (sections 3.3 and 3.4), policy makers will often seek to benchmark against similarly situated jurisdictions. For example, in developing economies, policy makers might find it more useful to consider what other developing economies have done than to examine the approach taken by jurisdictions operating in more advanced economies.
- **Similar patterns of energy use.** Policy makers could find it useful to examine the approaches of jurisdictions with similar emissions profiles and consumption patterns.

- **Pricing of key trading partners and competitors.** Policy makers might consider the carbon tax rates set by economies with strong trading ties to their own, in particular when taxing economic activities that can be moved. This comparative approach, taking into account post-tax prices of affected goods in competing jurisdictions, can reduce the risk of leakage of firms and markets across borders (chapter 7).
- **Linking to an ETS price.** Where examples of similarly situated jurisdictions employing carbon taxes are limited, carbon prices observed in ETSs may provide additional context for benchmarking. Although the ETS is a different approach than the carbon tax, both work on the basis of a price signal and so have a similar effect on actor behavior (chapter 2). Moreover, where a country is already participating in an ETS, it may use the ETS price to determine the tax on emissions that are not covered by the ETS. For example, both Portugal and Iceland derived their tax rates by examining the EU ETS carbon price and using this price as one of the factors determining their own carbon tax rate.

In carrying out the benchmarking study, policy makers should examine the approach and experience of a range of other jurisdictions, the tax levels they adopted, the scope of their taxes, and the impact those taxes have had.

6.2.5 The role of politics

While this discussion has identified four distinct approaches for setting the carbon tax rate, it is clear that much political compromise is involved as well. In some cases, the local context may be such that the carbon tax rate selected is entirely based on political feasibility. For example, it is reported that Norway's initial carbon tax rate was determined entirely through political negotiation.[32] In other contexts, such as the example of Australia discussed above, economic models and other approaches will play an important role in feeding into political negotiation processes. Whether politics is a small factor or major determinant, policy makers should carefully consider the political landscape as they analyze and recommend carbon tax rates for their jurisdictions (section 3.3.3).

6.3 DYNAMICS OF THE TAX RATE

Some jurisdictions will set a single carbon tax rate (or set of tax rates) that remains the same over time. In many cases, however, taxes follow a dynamic schedule or are otherwise adjusted over time. This variability can serve a number of purposes, such as allowing liable entities (and the economy as a whole) to adjust to the carbon tax over time, or to adapt to changing policy objectives and economic conditions.

Ideally, policy makers will consider the issue of tax adjustment processes at the same time as they determine which approach to use to set the tax rate, as the two can interact to affect important policy outcomes such as the amount of cumulative carbon abatement and the amount of cumulative revenue.

While many approaches can be used to address the question of whether and how carbon taxes should change over time, this section focuses on the most prominent options and compares the relative merits of each one.

6.3.1 Static carbon tax rate

A fixed, or static, tax is one that simply stays the same after its implementation. This approach has the advantage of giving a stable and highly predictable price signal. This stability facilitates private investment. Indeed, one of the advantages of carbon taxes over an ETS approach is that carbon taxes potentially provide more stable price signals. However, the advantages of stable prices depend upon governments' capacity to convince the liable entities that they will not adjust the rates in response to political pressure.

The disadvantage of this approach is that it can give a substantial shock to the economy if the introduction of the tax results in a sudden rise in the price of fuels without the opportunity to adjust practices (production technologies, building design, and the like) in anticipation. Also, the static approach does not allow for adjustments even in the face of new experience, changing policy objectives, or a rising SCC.

Where they do use static tax rates, jurisdictions might choose to index the rate to inflation, so that the tax rate in real terms is constant. For example, after its initial phase-in period concluded in 2012, Iceland stipulated that its tax rate would rise by at least the rate of inflation.

6.3.2 Gradually increasing carbon tax rate

Jurisdictions may choose to soften the impacts associated with suddenly putting a price on emissions by starting at a relatively low level and gradually increasing it to the long-term tax level intended. It takes time for liable entities to adjust to the new costs and adopt emission abatement technologies and practices. To achieve this gradual introduction, jurisdictions may set a trajectory for the carbon tax at the time of implementation. In practice, even with a very modest rate, Japan phased in its carbon tax from 2012 to 2016, the tax eventually reaching US\$3/tCO_2e. Similarly, in South Africa, the proposed tax rate would begin in 2017 at 120 Rand/ton of CO_2e (US\$8.50/ton) and increase by 10 percent each year through 2019 (145.20 Rand ≈ US\$9.50).

Jurisdictions can also set a target rate for a given date in the future while leaving flexibility as to the exact trajectory to that level. This is the approach taken by France, where in 2015 the government set the carbon tax rates for each

[32] IEEP (2013, 81).

year up to 2020, when it will reach €56/tCO_2e, and also set the rate for 2030 (at €100). However, rates for the years 2021–29 will be determined in subsequent legislation.

Gradual increases allow the economy to accommodate rather than experience a sudden major shock. This approach may also be taken to reflect the social discount rate, which is based on the idea that the atmosphere represents a fixed, exhaustible natural resource, and that the resource will only be used efficiently if the price (that is, the carbon tax rate) is increasing at a rate that matches the market rate of return on other investments.

6.3.3 Matching the social cost of carbon

This approach stipulates that the carbon tax will adjust to match official estimates of the SCC calculated or adopted by the jurisdiction. As a practical matter, given that the SCC is generally understood to rise over time, this approach will have some of the same advantages as the previous approach, that is, the tax rate itself will rise gradually, as if it were phased in.

6.3.4 Tax adjustment formula

Whether jurisdictions adopt a static tax rate or a dynamic trajectory, many important developments—as economic downturns, shifts in trade conditions and technological advances that might affect the SCC, or the public willingness to accept current tax rates, for instance—are difficult to foresee. For this reason, jurisdictions may choose to build in rate adjustments that are automatically triggered by key developments (e.g., if abatement targets are not reached).

The design of the carbon tax could include an adjustment formula that incorporates factors such as progress in meeting emission reduction targets (raising the tax rate if GHG abatement is falling behind schedule), revenue levels, inflation (linking the tax to some measure of inflation such as the CPI), exchange rate changes, and GDP growth. In the case of the Portuguese carbon tax, for example, the tax design incorporates an annual adjustment to reflect changes in the price on carbon in the EU ETS, while in Switzerland it is linked to compliance with emission reduction targets (box 17).

6.3.5 Periodic review

The carbon tax scheme can also include provisions for a periodic review and adjustment of the tax conducted by a panel of experts or government officials (chapter 10). The government can review tax performance, revenue raised, and changes in emissions on a regular basis and make changes if the tax overshoots or undershoots its targets. For example, each year Ireland reviews the status and performance of its carbon tax, and particularly marks what is happening to carbon prices in Europe. It then makes adjustments to the carbon tax if conditions warrant.

Under this approach, carbon tax legislation that incorporates the same factors listed for the adjustment formula, but without a specific mathematical constraint on the magnitude of the adjustment could also provide guidance to the periodic reviewers. While this guidance approach provides more flexibility and discretion than a strict formula, it potentially also allows for more political manipulation and ensuing uncertainty for liable entities.

6.3.6 Ad hoc political intervention

Jurisdictions can, of course, allow the political process to determine the adjustments to be made to the tax rate. For example, Finland has undergone a series of political adjustments to its carbon tax rate that, over the course of 25 years, have resulted in a much higher tax rate, but one that includes many elements typical of an energy tax rather than a pure carbon tax.

Jurisdictions should be wary of resorting to a pure political process to make adjustments to their tax rates. While investors deal in risk as a matter of course, the risk associated with political processes is often viewed with particular concern. Hence, liable entities facing a carbon tax might be reluctant to make investments in emission-reducing technologies and practices if they think the government will change the tax rate based on political rather than economic, technological, or environmental circumstances—that is, believe that a tax reduction is possible—thereby diminishing the business advantage of

Box 17. Case Study: Linking the Tax Rate to Emission Reduction Targets in Switzerland

Switzerland has one of the highest carbon tax rates in the world, at US$87/t$CO_2$e in 2016. This rate has gradually increased from US$10.68 when the tax was introduced in 2008. The tax rate is linked to compliance with economy-wide emission reduction targets Switzerland has set for sector covered by the tax. Where these targets are not met in a given year, the tax rate is raised based on a predefined formula, up to a maximum level of US$125.

The gradually rising tax rate has been identified as an important factor in incentivizing mitigation in the Swiss carbon tax. At the same time, providing a pre-defined mechanism for these rate increases is crucial, since without such a mechanism rate increases would be subject to parliamentary approval and would therefore be far less certain. In addition, linking the rate increase to compliance with mitigation targets plays an important role in raising awareness among the general population and private sector regarding progress in meeting these targets (Ecoplan, EPFL & FHNW, 2015).

reducing emissions. For this reason, whichever approach is taken to define the carbon tax rate dynamics, the decision-making process should be transparent and designed to minimize the negative effects of political influence.

6.3.7 Combining approaches to fit national circumstances

Many jurisdictions have combined these various approaches. For example, Iceland used benchmarking to set its initial tax rate, indexing the carbon tax to the carbon price reflected in the EU ETS. However, it phased in that rate, setting its rate to 50 percent of the EU ETS price in 2012, raising it to 75 percent of the EU ETS price in 2013, and the full EU ETS price in 2014. Following that period, the country stipulated that its carbon tax would rise by the rate of inflation or 3 percent per year, whichever was the highest.

By contrast, Norway employs a process for annual review and recommendations for tax adjustments. However, the recommendations can be the object of intense scrutiny and resistance, so ultimately the whole procedure is a political process informed by an annual review.

In choosing among the approaches to tax rate dynamics, jurisdictions will make decisions based on their individual priorities and circumstances. A common thread in these decisions is the tension between predictability and adaptability. A government might have legitimate, efficiency-driven reasons for wanting to retain the capacity to adjust tax rates in the face of new information, greener technologies, or changing circumstances. However, private parties will be more willing to invest in cleaner technologies (in energy-efficient equipment, renewable energy, etc.) if the price signal is reasonably foreseeable. Of course all businesses make investments in the face of uncertainty and risk. However, political risks and uncertainties tend to be more difficult to predict and manage in a way that encourages efficient investments. For this reason, a gradually increasing tax rate holds strong advantages. Similarly, the automatic adjustment formula or review by nonpolitical experts can help ensure predictability; unfortunately, few jurisdictions have implemented such a process and so few pertinent case studies exist.

Key Considerations

- Setting the tax rate is among the most important decisions facing jurisdictions when they adopt a carbon tax. The tax rate chose, coupled with the decision on the coverage of the tax, will determine the amount of abatement expected, the revenue raised, and to a great extent the overall economic impact of the tax.
- Several approaches can be used as a starting point for determining the tax rate, each reflecting different core policy objectives. Identifying and prioritizing these objectives is therefore a crucial first step in setting the right rate.
- While existing carbon tax rates vary widely across jurisdictions, the vast majority have begun at a relatively low level and gradually increased over time. This approach allows liable entities—and the economy as a whole—to adjust to the tax, and provides time to invest in mitigation strategies.
- At the same time, setting the rate low initially, without having a trajectory or mechanism in place for raising it in the short to medium term, creates the risk of the low rate being locked in, thereby severely limiting the environmental effectiveness of the tax.
- In choosing the right approach to adjusting the tax rate over time, policy makers must balance the need to provide stability and predictability to investors with the desire to retain some flexibility to be able to take into account changing circumstances.

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7 AVOIDING UNWANTED EFFECTS OF THE CARBON TAX

At a Glance

In designing a carbon tax, it is important to consider the potential for unintended effects to arise, and to develop measures to address these. Two potential effects are particularly important in this context:

- **Carbon leakage,** which refers to the risk that a mitigation policy causes a reduction in emissions in the jurisdiction where it is implemented but inadvertently leads to an increase in emissions in jurisdictions without equivalent policies. This could occur through firms in other jurisdictions gaining market share, or through emitting activities relocating outside the jurisdiction.
- **Negative distributional impacts**, which can occur where the carbon tax falls disproportionately on certain groups, and in particular where these are vulnerable groups such as low-income families, the elderly, or people in disadvantaged regions.

No significant evidence has yet been found of carbon leakage occurring in practice, and it is generally accepted that other business costs will typically be far more significant determinants of competitiveness than carbon pricing. At the same time, losses in short-term competitiveness (and potential associated leakage) may be compensated by long-term competitiveness gains associated with being an early mover in adopting efficient forms of production. Nonetheless, where any such competitiveness losses do result in leakage, this creates a potential environmental integrity risk.

The distributional effects of the carbon tax will often depend on the specific context, as well as on how the tax is designed. While in some cases regressive effects may occur, in other cases the carbon tax may even have progressive effects. Indeed, which effects are considered "negative" and which are considered "positive" will also depend on context-specific factors.

The context-specific nature of the risks associated with leakage and distributional impacts means it is important for jurisdictions to conduct a robust analysis of the potential risks before deciding to adopt measures to mitigate these. Ex ante modeling can be useful in predicting risks, while ex post modeling can assess how these predictions have played out in practice. In the event that jurisdictions do decide to adopt mitigation measures, it is important to develop criteria that allow for identifying those regulated sectors and entities most at risk and avoid applying overinclusive definitions that jeopardize the effectiveness of the carbon tax.

A range of potential measures exist that can be designed to address the risks associated with either leakage or distributional impacts:

- Tax-reducing measures, such as exemptions and reductions, directly eliminate or reduce the amount of carbon tax paid by the liable entity. Permitting liable entities to substitute tax payments with surrendering offsets provides a variation on this approach.
- **Support measures,** such as output-based rebates, support programs, and other subsidies, do not reduce the amount of carbon tax paid, but instead provide a separate form of support that reduces taxpayers' overall financial burden on account of the carbon tax.

A number of additional measures may be applied to reduce leakage risks. For example, border carbon adjustments and consumption-based taxation can extend the effective reach of the tax by subjecting imports to the same tax as domestic goods. Tax-coordinating measures, such as reciprocal arrangements with other jurisdictions on carbon price floors, reduce the risk of leakage by leveling the playing field between them.

What specific measures are adopted has important implications for the effectiveness of the carbon tax, and so it is important to carefully consider their relative advantages and disadvantages.

7.1 INTRODUCTION

Carbon taxes are designed to alter the economic costs of certain behaviors that produce GHG emissions. While they can be expected to reduce emissions and may bring a range of additional benefits (section 3.2), the resulting economic signal could also have some unwanted effects. For example, where the additional costs make companies in certain sectors less competitive compared with companies in jurisdictions with the same or higher emissions intensity, "carbon leakage" could occur, negating the environmental benefits of the tax. Moreover, where a carbon tax places a disproportionate burden on vulnerable groups or certain geographic regions, it may have negative distributional or social impacts.

These potential negative effects of carbon taxes are often important for policy makers in many jurisdictions. It is therefore important to understand the nature of the associated risks, how to assess their probability of materializing, and how to create an effective policy to address them while maintaining the effectiveness of the carbon tax as a climate and economic policy tool.

Against this background, this chapter provides guidance on understanding and assessing risks related to leakage and negative distributional impacts, and on the measures available to address these. It begins by providing an introduction to leakage and distributional impacts (section 7.2). It goes on to provide guidance on assessing leakage and distributional risks, for instance, through the use of models and the development of tests to determine the risks for specific sectors, companies, or citizens (section 7.3). Finally, it sets out the principal policy tools available to mitigate leakage and distributional risks, and evaluates their respective advantages and drawbacks, while providing guidance on their use in practice (section 7.4).

7.2 UNDERSTANDING LEAKAGE, COMPETITIVENESS, AND DISTRIBUTIONAL IMPACTS

To be able to assess any potential risks relating to leakage, competitiveness, and distributional equity that may be presented by a carbon tax, it is necessary to first understand how these risks arise and be familiar with some key concepts surrounding their causes and effects. This section therefore provides an introduction to leakage, international competitiveness, and distributional equity.

7.2.1 Leakage and international competitiveness

Some overlap exists between the risks associated with carbon leakage and those associated with international competitiveness; the two are often considered closely related. At the same time, they are fundamentally distinct concepts—where leakage relates to the environmental effectiveness of a carbon tax, competitiveness relates to economic impacts. It is therefore important to understand each in terms of the specific factors shaping these phenomena. This subsection thus begins by examining leakage and the possible channels through which it may arise, and subsequently discussing its relationship with international competitiveness.

7.2.1.1 Leakage channels

Carbon leakage occurs when an emission-reduction policy such as a carbon tax inadvertently causes an increase in emissions in other jurisdictions that do not have equivalent emission-reduction policies. Past analyses have identified three channels for leakage and one channel for "reverse leakage" (where carbon regulation in one jurisdiction triggers a reduction in emissions in another jurisdiction), summarized in table 20.[33]

Policy makers generally focus on the first two channels, as they constitute risks (rather than reverse leakage, which is a co-benefit), and have a number of options for leakage mitigation. Leakage through the fossil fuel price channel is harder to target directly through policy because of the complex determinants of global fossil fuel prices, resulting in a lack of leakage mitigation options.

7.2.1.2 International competitiveness

International competitiveness refers to the ability of companies to maintain or increase their international market share. One of the key determinants of companies' competitiveness in a given industry is input costs, and for energy-intensive and/or emissions-intensive production, a carbon tax will increase input costs, which may put covered firms (or sectors) at a competitive disadvantage. Where this leads to market share shifting to firms that have the same or higher emission intensity, this undermines the environmental effectiveness of the carbon tax, known as "inefficient" carbon leakage.

It is important to distinguish this form of leakage from the situation where increased costs due to the carbon price result in a shift in production to firms with a lower emission intensity. This type of leakage in fact reflects the policy objective pursued by putting a price on carbon since it leads to emission reductions, and can therefore be considered "efficient" carbon leakage. It is important for policy makers to distinguish these two kinds of leakage when devising a leakage mitigation policy, as providing assistance to protect firms that would otherwise lose market share to more efficient firms would itself undermine the environmental effectiveness of the tax.

It is also important to distinguish between short-term and long-term competitiveness effects. A carbon tax, while potentially creating a short-term competitive disadvantage

[33] Partnership for Market Readiness, 2015.

Table 20. Channels of Leakage and Reverse Leakage

	LEAKAGE CHANNEL	DESCRIPTION
Leakage	The output channel (short-term competitiveness)	Higher carbon emission costs cause firms affected by the carbon tax (covered firms) to lose market share to those firms not covered by the carbon tax (uncovered firms).
	The investment channel (long-term competitiveness)	Carbon tax leads to reduced investment in maintenance capital to sustain output levels from covered firms and possible long-term closure of plants in the taxing jurisdiction. At the same time, investment increases and new plants start production in non-taxing jurisdictions.
	The fossil fuel price channel	Firms in taxing jurisdictions are likely to reduce fossil fuel consumption, which can lower the price of globally traded fossil fuels, triggering increased consumption in non-taxing jurisdictions.
Reverse leakage	Technological spillovers channel	A carbon tax spurs innovation in the taxing jurisdiction, leading to the development of more cost-effective technologies that are subsequently adopted in non-taxing jurisdictions.

for some firms, also creates an economic incentive for covered firms to invest in more efficient production methods that, in the medium term, can increase their competitiveness in relation to uncovered firms using business as usual (BAU) production methods. In the long term, firms able to compete in a global market where low-carbon production is highly valued may also enjoy an early mover advantage. Thus, it is worthwhile for policy makers to balance expected short- and long-term impacts in determining whether to provide firms some kind of support.

The cost impact of carbon pricing and the associated risk of carbon leakage must be seen in the context of a range of other business costs. Other input cost differentials, such as background energy prices and labor costs, are typically far more significant determinants of competitiveness than carbon pricing. Other important, non-input competitiveness factors include level of labor skill, brand loyalty, and proximity to markets (section 7.3).

Finally, it is important to distinguish the impacts on the competitiveness of firms with the impacts on countries or jurisdictions in which they are based. Competitiveness at the international level is far harder to define and understand than competitiveness between firms. Countries are one another's export markets and sources of imports, and the trade balance between them is not a straightforward zero-sum game for market share. Further, it is recognized that the quality of infrastructure, institutions, education levels, and other structural factors can be far more important determinants of national productivity than environmental legislation.[34] Policy makers should thus be wary of arguments that conflate the competitiveness of certain firms or sectors with international competitiveness.

[34] Partnership for Market Readiness, 2015.

7.2.2 Distributional impacts

A carbon tax can have significantly different impacts on different sections of society, depending on a range of factors regarding both its design and the geographic, economic, and social realities of the jurisdiction. Where the carbon tax falls disproportionately on certain groups, this can have negative distributional effects—it distributes the cost of the carbon tax in an uneven or unfair way. Though this can happen in a number of ways, this chapter focuses on two types of distributional impacts:

- **Income groups.** A carbon tax may affect more heavily one income group than another. Particularly, it has been suggested that low-income households spend larger shares of their household budgets on energy than the rich; therefore, where a carbon tax increases energy prices, it hits the poor harder. If this happens, the carbon tax can have a regressive effect.
- **Geographic regions.** A carbon tax may also fall more heavily on certain regions. For example, regions with high concentrations of emissions-intensive industries or that rely on extraction of fossil fuels may experience greater economic impacts than regions with a larger share of service-based industries. Similarly, regions where people spend more on energy bills because of climate conditions (e.g., extreme heat or cold) could be disproportionately affected by rises in energy bills, as is the case in the northern regions of British Columbia, while people in rural areas might have higher exposure to transport fuel costs.

Because energy consumption and income patterns vary significantly between different jurisdictions, it is impossible to say that carbon taxes will always be regressive or progressive, or that they will fall disproportionately on urban or rural populations. The direction of either of these effects will depend on a range of factors, including the level of economic development of the jurisdiction. These factors are discussed further in the following section.

7.3 ASSESSING LEAKAGE AND DISTRIBUTIONAL RISKS

Where policy makers are considering the development of policies to mitigate leakage or distributional risks, it is important to understand two things: (i) whether either of these potential risks associated with the carbon tax is substantial, and, if so, (ii) which sectors or subset of actors are these risks likely to materialize for. Understanding the answers to these questions will enable policy makers to decide whether mitigation measures are required and, if so, which sectors or specific actors should be targeted by those measures and what level of assistance is required. A robust assessment of the nature and extent of risks can help to design a policy that adequately addresses those risks, while avoiding undermining the environmental benefits of the carbon tax or unnecessarily straining public budgets.

This section first sets out some considerations in assessing the potential negative impacts that may arise from a carbon tax. It goes on to describe how ex ante modeling can be used to help predict the possible impacts of a planned carbon tax or from different potential carbon tax designs, and then considers the development of criteria for determining which sectors or actors are eligible for mitigation relief measures. Finally, it considers how ex post modeling can be used to periodically assess the effects of a carbon tax, and thereby inform future adjustments to the carbon tax design.

7.3.1 Initial considerations

The way a carbon tax is designed has an important bearing on the potential for carbon leakage and distributional impacts, respectively, to arise.

First, where the majority of entities affected by a carbon tax are consumers and nonenergy-intensive and nontrade-exposed businesses (e.g., the services sector), leakage is unlikely to pose a real risk. This is frequently the case, for example, with taxes on transport and space-heating fuels. Taxes on electricity generation also generally present low leakage risks, since this sector is often less trade-exposed and companies can typically pass costs through to consumers. On the other hand, taxes that target heavy industry have a relatively high likelihood of entailing leakage risks.

In the case of distributional impacts, the situation is at least partially inverted. Taxes on fuel and electricity will typically be passed through to consumers and in many cases the poorer sections of society—if not given additional government support—will have fewer options to reduce their energy use. Thus, these taxes risk having negative distributional impacts. On the other hand, in the case of heavy industry, the direct effects on consumers are often limited. Nonetheless, some regions or sections of society may be disproportionately affected if reduced output in certain sectors leads to job losses.

One way in which taxes ultimately paid by consumers could lead to leakage is if those consumers have the option to purchase taxed goods in another (non-taxed) jurisdiction, particularly in border areas. This has been a concern, for example, regarding the Irish and Danish carbon taxes. Most jurisdictions will have strict legal limits on the amount of products subject to excise tax (e.g., fuel and alcohol) that can be imported without additional tax being paid, and so where this takes place at anything other than on a very small scale, it will usually amount to illegal smuggling. It is therefore principally an enforcement issue (section 9.4).

It is worth noting that there is a similar risk of businesses smuggling fuels across borders, though in well-regulated systems this will generally be more difficult to conceal. On the other hand, transport companies whose vehicles frequently cross borders between taxed and non-taxed jurisdictions can take advantage of this fact by simply refueling in the non-taxed jurisdiction.

7.3.2 Using ex ante modeling to estimate leakage and distributional risk

Where jurisdictions have reason to believe that a proposed carbon tax may lead to leakage or negative distributional impacts, ex ante modeling can be useful in testing these assumptions and helping to determine the risks involved. Ex ante models provide evaluations of proposed new policies, forecast into the future. They generally involve comparison of a “with policy” and “without policy” simulation, the latter based on a BAU scenario.

Basically, two types of ex ante models can be used to assess leakage or distributional risks under a carbon tax , provided they have the appropriate levels of detail:

- **Partial equilibrium models.** These models examine the effects that a carbon tax can be expected to have on particular sectors of the economy. This can be useful for assessing leakage risks for specific sectors. They are less useful for assessing the distributional impacts on different income groups, though they may be used for assessing risks in a specific region.
- **Computable General Equilibrium (CGE) models.** CGE models are large-scale representations designed to capture the interplay among a range of economic forces, particularly among economic sectors. This can be used for assessing leakage or distributional impacts on the economy as a whole.

Detailed guidance on the kinds of modeling approaches available and how they can be used for different aspects of carbon tax design is provided in chapter 4. The following sets out, based on experience with models of the effects of carbon pricing,[35] some of the key considerations that should be kept in mind when using models to identify risks related to leakage or negative distributional impacts.

7.3.2.1 Considerations relating to leakage or negative distributional impacts

When looking at leakage risks and possible negative impacts on income distribution, the following aspects should be borne in mind:

- **Models can provide useful insights, but also have their limitations.** In general, it is useful for policy makers to review ex ante modeling studies to gain insight into the nature and magnitude of potential impacts, particularly as a way to test claims made by economic entities that have a vested interest in exaggerating the potential negative impacts that secondary effects could have on the environment and the domestic economy. They should nonetheless be used with caution, as they are subject to much uncertainty and their outcomes can be affected by the structures of the models and the underlying assumptions on which they are based.
- **The accuracy of outcomes will depend on the availability of reliable inputs.** Models rely on a large number of inputs to work, and where sufficient and reliable data are not available the results obtained are not likely to be reliable either. Models will require well-developed, BAU forecasts, elasticities of demand and supply for key factors, relative costs of production, and economic growth rates. In the case of models of distributional impacts, models will require detailed household income and spending data. Leakage models will require data on international trade in given products and international trade dynamics.
- **Different reference cases and policy questions can be used to answer different questions.** In both CGE and partial equilibrium models, the reference cases are historical in some cases and forecast in others. These two approaches can serve different purposes. The historical reference case is designed to address the question "what would have been the impacts in the past if the policy had been adopted in the past?" The forecast approach supports estimation of "what will happen in the future if the policy is adopted now (or in the near future)?" The advantage of the former approach is that the reference case does not need to be estimated; it has actually been observed. However, as a tool to support the formulation of new policy, which necessarily takes place in the present, it does not allow for adjustments in important factors that might be expected and incorporated for the future, such as population changes and further economic growth.

7.3.2.2 Specific considerations in assessing distributional impacts

When looking at the possible distributional impacts, the following factors should be duly considered:

- **Impacts depend upon context.** Broadly speaking, it appears that carbon taxes are more regressive in developed economies. Conversely, a carbon tax may be progressive in less developed economies. For example, a carbon tax in China seems to favor low-income households because they use so little fossil fuel (Brenner et al. 2006). Research results also suggest that a carbon tax would fall more heavily on urban than rural households in China, for the same reason.
- **Impacts depend on the level of the tax.** When modeling the distributional effects of a carbon tax, it is important to consider the level of the tax and whether that will change over time. For example, a CGE model of a carbon tax in Canada found that the tax would be progressive at low levels, but become regressive at higher levels (Dissou and Siddiqui 2014).
- **Impacts depend on the way income is measured.** Modelers generally use two primary definitions of income: annual income and lifetime income. A CGE model of a hypothetical carbon tax in the United States suggests that the extent of regressivity measured in terms of annual income is twice as high as when measured using lifetime income (Grainger and Kolstad 2009). This is, in part, because lifetime income in the United States is more evenly distributed than income in any single year.
- **Impacts depend on the breadth of the tax.** The distributional effects of a tax may depend on the coverage of the tax. A study of the Netherlands, for example, found that a broad GHG tax was more cost-effective and slightly less regressive than a comparable but narrower tax on carbon alone (Kerkhof A. et al. 2008)

7.3.2.3 Specific considerations in assessing leakage impacts

When assessing the possible impacts of leakage, the following factors should be duly considered:

- **Different types of models yield different results.** In particular, estimates of leakage from CGE models tend to be considerably lower than those from partial equilibrium models. While CGE estimates tend to find risk probabilities under 15 percent, and in some cases predict no leakage at all or even a negative leakage, partial equilibrium study estimates tend to be higher, but

[35] On models addressing leakage, see the summary provided in table 1 of Partnership for Market Readiness 2015. Many of the models described in annex 4A and annex 4B of this Guide address distributional issues.

also have much wider ranges. This may be explained by the tendency of partial equilibrium studies to focus on industries that are expected to have the highest leakage rates. The different results from CGE and partial equilibrium models indicate that different models will be differently suitable, depending on whether policy makers are more concerned about leakage across the aggregate economy or in one or more strategic sectors.

- **Partial and general equilibrium models should ideally be used in concert.** While the outcomes of partial and general equilibrium approaches are somewhat difficult to reconcile, their different strengths and focuses make both approaches valuable to modeling leakage, and they should ideally be used in combination. The drawback of this approach is the time and modeling effort associated with iterating models, and the potential difficulty in achieving consistency between results from the two approaches. In the absence of a combined approach, general and partial equilibrium results may be more easily reconciled by separately reporting sector-level results from general equilibrium models to ensure a like-for-like comparison.
- **Models that factor in measures in other countries will provide a more realistic result.** In particular, given the concerted and scaled-up climate mitigation efforts expected in the wake of the Paris Agreement, it is important to seek to factor in actors in key competitor countries when modeling the leakage risk posed by a carbon tax. The analysis by Paroussus et al. (2014), for example, illustrates the importance of this point, demonstrating a (modeled) reduction in leakage from 28 to 3 percent when carbon pricing was extended from EU only to the EU, the United States, and China.

7.3.3 Criteria for determining the need for mitigation measures

Where jurisdictions determine that the risks of leakage or negative distributional impacts are significant, they still need to decide whether to adopt leakage mitigation measures. To facilitate this decision process, and to make it more objective, they may adopt a set of criteria for determining the eligibility of specific economic groups, sectors, or companies for those measures. Adopting such criteria helps to make the provision of relief measures more transparent and can allow for greater distinction between subsectors or population groups, helping to better focus measures on where they are actually needed.

7.3.3.1 Criteria for leakage and international competitiveness mitigation measures

To date, jurisdictions that have tests to determine the exposure of a given sector or entity to leakage have focused on two criteria:

- **Carbon intensity.** This captures the impact that carbon pricing has on a particular firm or sector by assessing the volume of emissions created per unit of output, revenue, profit, or similar economic metric (the term “emission intensity” can be used interchangeably in this context). As carbon leakage is driven by carbon emission cost differentials between jurisdictions with and without carbon prices, greater impacts of a carbon price on sectors or firms can in principle be expected to correlate with greater leakage.
- **Trade exposure.** This is used as a proxy for the ability of a firm or sector to pass on costs to the consumer without significant loss of market share, and hence their exposure to carbon prices. Trade, or the potential to trade, allows competition between producers in different jurisdictions and therefore exposes firms subject to the carbon tax to competition from firms not subject to a carbon price (or subject to a lower price), thereby limiting their ability to pass through costs.

In most cases (e.g., Australia, France, South Africa, and Switzerland) jurisdictions have applied a combination of both criteria to determine leakage exposure. Some jurisdictions (e.g., Denmark, Finland) have, on the other hand, only looked at whether a company is carbon- or energy-intensive.

While jurisdictions in practice have to date focused on these two criteria, it is broadly accepted that, while they are important, a range of other factors are also likely to play a significant role in the leakage exposure of a sector or firm. The reluctance to incorporate these additional factors can in many ways be explained by the challenges presented in accurately assessing them.[36] Nonetheless, to the extent that relatively reliable data are available, inclusion of these factors can support a more accurate assessment of the extent of leakage risks faced by particular actors or sectors.

Table 21 presents a summary of the main factors behind leakage risk, which incorporates the two most common ones described above, as well as a several other factors.

7.3.3.2 Criteria for measures to address negative distributional impacts

The criteria by which a jurisdiction judges whether to address a potential negative distributional impact are highly dependent on politics, culture, and capacity. However, policy makers may consider the following factors in making this decision:

- **Direction of the distributional impact.** Not all distributional impacts are negative. There is, for example, some evidence that in developing economies a carbon tax is progressive, falling disproportionately on the high-income households, which can afford a substantial energy component in their budget (Callan et al. 2009). In these cases, jurisdictions might consider treating the carbon tax as an efficient income redistribution mechanism.

[36] See further Partnership for Market Readiness, 2015 (section 4.2).

Table 21. Factors behind Leakage Risk

CATEGORY	FACTORS INFLUENCING RISK	EXPLANATION
Direct costs	Emission intensity of the production process	The lower the CO_2 intensity of production, the lower the tax exposure and hence a reduced competitive disadvantage per unit of output compared with the same, non-taxed product.
	Availability of abatement options	Limited abatement options will limit the ability of firms to lower their tax exposure and compete with uncovered firms.
	Cost of abatement options	More expensive abatement options limit the cost effectiveness of adaptive measures to lower tax exposure.
Indirect costs	Reliance on taxed products	Uncovered firms—and in some cases even covered firms—in a taxing jurisdiction will be affected by a carbon tax if it leads to an increased cost of their inputs, such as electricity.
	Perceived investment risk	A carbon tax may increase the perceived riskiness of carbon-intensive investments, which may lead to increased interest rates on loans for liable entities.
Cost pass-through capacity	Ability to pass increased costs through to customers	Liable entities that cannot pass through their costs to customers (e.g., because of price controls or sensitivity of consumers to prices) will be at a competitive disadvantage with respect to nonliable entities.
Exposure to competition	Extent of international trade in relevant products	The more a taxed product is internationally traded, the more covered firms are likely to be subject to increased competition from products produced by firms in jurisdictions without a carbon price, both in the domestic market and international market.
	Competitiveness of sector	Where many firms compete in a market, including a substantial number of unregulated firms, the probability of market share shifting to unregulated firms will be much higher.
International policies	Existence of carbon pricing or similar policies in competing jurisdictions	If competing countries introduce carbon pricing policies of equivalent stringency, this should lessen the risk of leakage, though this is subject to leakage mitigation measures in those jurisdictions.
Mobility	Ability to shift production overseas	Production may be physically bound to the jurisdiction in which products are consumed (e.g., infrastructure, construction, certain agricultural goods).
	Upfront capital requirements	Some industries require significant public infrastructure and production facilities, and a skilled labor force. Where these enabling conditions exist in a taxing jurisdiction, loss of competitiveness to entities in a non-taxing jurisdiction without these enabling conditions is unlikely.
	Mobility of capital	For jurisdictions in which foreign direct investment represents a high share of total investment or where domestic investment can easily be shifted abroad, the leakage risk will be higher than for jurisdictions where these conditions don't apply.

- **Magnitude of the distributional impact.** Where the costs of a carbon tax are particularly burdensome for low-income households, jurisdictions may be inclined to adopt mitigating measures. In some cases, however, even where carbon taxes are expected to be regressive, jurisdictions may decide not to try to mitigate that outcome if the magnitude of the regressive effect is relatively small, as some studies have suggested (Zhang and Baranzini 2004). This is particularly relevant where the programmatic and economic costs of redistributing income are substantial and are therefore too high to justify the social benefits of redistributing income.
- **Context of the distributional impact.** In some cases, the incidence of a carbon tax may fall more heavily on certain regions of a jurisdiction than others. While this might incline policy makers to seek measures to mitigate the uneven impact, it is worth considering the context behind the impact. For example, if the disadvantaged region has been slow to adopt available green technologies or has refused to adapt to clear economic and social signals, the jurisdiction might deem it fair to expect the slow adapters to bear the full cost of their emissions.

Where jurisdictions do decide to target mitigation measures at specific groups, they will often define eligibility based on existing categories and definitions used to determine who is eligible for welfare assistance. For example, in Ireland, the Better Energy Warmer Homes Scheme is available, among others, to those who are eligible for unemployment ("job seekers") benefits or allowances for single-parent families.

7.3.4 Using ex post evaluations to review leakage and distributional impacts

Ex post evaluation of leakage and distributional impacts can help policy makers determine how significant any negative effects are under the carbon tax and adjust the scope and breadth of assistance accordingly. This can help ensure, on the one hand, that measures to address these impacts are achieving their aim of mitigating leakage and decreasing distributional impacts, but also to highlight where measures may be too generous and could be scaled back without significantly increasing the negative effects.

Ex post evaluations generally take one of two forms: empirical econometric studies and industry or citizen surveys. The survey approach tends to be dismissed by policy analysts as subject to the biases of respondents. The criticism of surveys arises from the fact that those who are in the best position to provide first-hand observations of carbon tax impacts are the same individuals and firms who are likely to experience the greatest economic impacts. Thus, they also have the greatest incentive to exaggerate the impact and may not provide a reliable account of whether negative effects have materialized, though they may give an indication of the upper limit of the negative impact. An alternative is to survey third parties with close knowledge of the operations of relevant firms.

Econometric studies rely on statistical analysis to infer a relation between changes in key economic factors (e.g., a new carbon price) and changes in observed effects (e.g., household income distribution). Econometric studies of leakage have shown little evidence of significant carbon leakage in jurisdictions that have implemented carbon pricing.[37] However, this finding may have been influenced by specific factors such as the fact that most jurisdictions have adopted measures to address the risk of leakage as part of their carbon taxes. Thus, it remains useful for jurisdictions to conduct their own econometric analysis on a periodic basis to assess the actual effects of their carbon tax.

Possible approaches to conducting an ex post evaluation of the carbon tax are further discussed in chapter 10.

7.4 DESIGNING MEASURES TO MITIGATE UNWANTED IMPACTS

Policy makers can adopt different measures if they decide to support firms considered to be subject to leakage risks or vulnerable sections of society. These measures can be grouped by type of support.

Measures that can target leakage and distributional risks comprise:

- **Tax-reducing measures, such as exemptions and reductions.** These directly eliminate or reduce the (carbon) tax burden faced by the liable entity. Permitting liable entities to substitute tax payments with surrendering offsets provides a variation on this approach, since it also allows entities to reduce their tax obligations.
- **Support measures, such as output-based rebates, support programs, and other subsidies.** These do not reduce the amount of carbon tax paid, but instead provide a separate form of support that reduces taxpayers' overall financial burden from the carbon tax.

Measures targeting leakage only comprise:

- **Border adjustments and consumption-based taxation, such as border carbon adjustments.** These extend the effective reach of the tax by subjecting imports to the same tax as domestic goods and exempting exports.
- **Tax-coordinating measures, such as reciprocal arrangements on carbon pricing with other jurisdictions.** These reduce the risk of leakage by reducing or eliminating the price differential with competing jurisdictions, which is the main factor underlying the leakage risk.

[37] See table 2 of Partnership for Market Readiness 2015 for a summary of empirical studies of leakage.

Table 22. Overview of Measures to Address Leakage and Distributional Risks

		Measure	Pros	Cons	Examples
Measures addressing leakage and distributional risks	Reducing carbon tax payments	Exemptions	Relatively straightforward to implement Can be directly targeted at affected industries Unlikely to present international legal challenges Can be made contingent upon emission reduction agreements	Negate price signal of tax Difficult to determine appropriate level and extent ex ante Risk of domestic legal challenge from non-exempted industry Loss of tax revenue Contrary to polluter pays principle	British Columbia, Japan, South Africa, Switzerland
		Reduced rates			Sweden, France
		Rebates on carbon tax payments			Denmark, Ireland, Finland
		Offsets	Incentive for emission reductions in uncovered sectors Incentivize private investment in emission reductions	Administratively complex Reduced tax revenues Environmental integrity challenges	Mexico, South Africa
	Support measures	Output-based rebates	Retain price signal Strong leakage protection	High and uncertain costs to public budget Significant data requirements Reduce incentive to shift to other products	Sweden NO_x tax
		Support programs	Retain price signal and offer additional emission reduction incentive Popular with industry groups Flexible in design, as can take the form of grants of tax credits, loans, guarantees etc.	Costly to public budget (though often less than exemptions) May present challenges as far as complying with state aid rules is concerned	South Africa, Australia, Ireland, Switzerland, Japan
		(Non-carbon) tax reductions	Retain price signal Potential for net positive effect on business and economy	Cost to public budget Difficult to target directly at affected entities	British Columbia, France
		Flat payments	Retain price signal Simple for citizens to claim Popular with general public Potential for net positive social and economic benefits	Cost to public budget	
Measures addressing leakage only	Border adjustments and consumption-based taxation	Border carbon tax adjustments	Maintain price signal for domestic industry Prevent free-riding by companies from non-taxing jurisdictions Do not put pressure on public budgets	Politically unpopular internationally and risk damaging international relations Administratively challenging Potential negative economic impacts on importers May be challenged as trade barrier under WTO or other trade law, though well-designed measures can likely be defended	California ETS
	Tax-coordinating measures	Tax-coordinating measures	Retains domestic price signal Leverages domestic carbon price to encourage carbon pricing in partner jurisdictions No domestic administration needs	Difficult to negotiate across many countries, so may be unworkable for sectors with large numbers of international competitors	None

These different types of measures and their main benefits and challenges are summarized in table 22 and discussed in more detail in the following subsections.

7.4.1 Measures that can target leakage and distributional risks

The following describes two categories of measures that can broadly be designed to either address leakage risks or distributional risks.

7.4.1.1 Reducing carbon tax payments

Jurisdictions can reduce the amount of carbon tax paid by companies deemed to be exposed to leakage risks or by vulnerable sections of society in a number of ways, most commonly through:

- **Exemptions.** In the case of downstream taxes on direct emissions, the most straightforward way to reduce companies' tax burden is to provide an exemption from tax obligations. Full exemptions completely exclude a company from direct tax obligations (i.e., those on their direct emissions), while partial exemptions allow it to avoid paying tax on a certain portion of its emissions. This is the case, for example, in South Africa, where under current proposals all covered sectors will have a tax-free threshold of 60 percent of their emissions, and sectors at risk of leakage will be entitled to exclude an additional 10 percent. An alternative approach is to set a threshold below which no tax is payable, and so only require liable entities to pay tax on their emissions above that threshold. For example, the threshold could be set to a benchmark representing the average emissions using the most efficient practices, giving companies an incentive to reduce their emissions to this threshold (sometimes known as a "target baseline tax"). Exemptions can also be provided to certain regions, such as remote regions with relatively few mitigation options, as in the case of coal for electricity generation used on Okinawa Island in Japan.
- **Reduced tax rates.** Jurisdictions can set multiple tax rates, offering lower rates to sectors deemed at risk of leakage. This was the approach initially taken by Sweden, where a two-tier system until recently applied a lower tax rate to energy-intensive and trade-exposed sectors.
- **Rebates on carbon tax payments.** In the case of upstream and midstream taxes, any (full or partial) exemption of downstream actors will, in practical terms, usually be effected through a rebate, that is, repayment of all or part of the carbon tax paid by a liable entity, such as in Denmark (box 18). This is because the downstream actor being exempted does not pay the tax directly, but through the purchase of taxed products (e.g., fuel, electricity). As long as the rebate is claimed by the taxpayer, the ultimate effect is very similar to an exemption. Rebates do, however, require administration for examining and verifying rebate applications.

Exemptions, reductions, and rebates are the most direct means of addressing leakage risks and distributional

Box 18. Case Study: Linking Exemptions and Rebates to Agreements in Denmark and Switzerland

Denmark and Switzerland faced a similar challenge in designing their carbon taxes, namely how to avoid placing a heavy burden on emissions-intensive and trade-exposed industries, while avoiding reducing the environmental effectiveness of the carbon tax. The two jurisdictions took a similar approach to addressing this challenge, namely to make eligibility for exemptions (Switzerland) and rebates (Denmark) contingent upon companies entering into agreements with the government under which they commit to reduce their emissions (Switzerland) or energy use (Denmark). Agreements under both systems are legally binding undertakings that provide for penalties in case of noncompliance. Agreements can be entered into with individual companies or with groups of companies, for example, covering a given sector.

Experience with agreements in both jurisdictions has for the most part been positive. The Danish scheme enjoyed high industry engagement, with 98 percent of heavy process industries entering into agreements. Compliance rates were high, with only a handful of noncompliance cases. Effects on emissions were believed to be significant, though assessments were subject to uncertainties. Key drawbacks were the relatively high administrative cost associated with the program, as well as the forgone public revenue as a result of the exemption.*

The Swiss scheme, meanwhile, has seen successful in engaging companies at high management levels in the challenge of identifying and realizing emission reduction opportunities. The system has also seen the development of a new service industry to support companies in reducing their emissions, and helping to develop knowledge and expertise in the country. There is, however, little analysis comparing the emission reductions achieved through these agreements with those that would have been achieved in the absence of the application of exemptions.

* Ericsson, 2006.

concerns, since they directly reduce or eliminate altogether the effect of the tax on companies and consumers. They are also relatively straightforward to implement from an administrative point of view, as most jurisdictions will already have mechanisms in place for applying and managing exemptions, differentiated rates, and rebates within their tax system. However, in the case of upstream taxes, capacity will be needed to review and verify rebate applications. Additionally, it is worth noting that getting the design of exemptions and rebates right can be challenging, particularly elements such as accurately identifying the entities that are at real risk of leakage or negative distributional effects.

The key drawback of these tools is that they essentially eliminate or dampen the price signal provided by the carbon tax, thereby removing or reducing the incentive to reduce emissions. This compromises the effectiveness and environmental integrity of the tax, while also reducing revenues and going against the polluter pays principle. The dampening of the price signal reduces the effective coverage of the carbon tax, which can in turn increase the cost of mitigation in other sectors. It also forgoes a valuable revenue source, which could otherwise be used for a range of productive purposes (chapter 8).

In determining whether to allow exemptions and reductions, and if so, their extent, policy makers need to balance the cost of these measures for the carbon tax policy, in terms of reduced coverage, mitigation ambition, and revenue, against the benefits for the affected sectors and the broader economic implications. Where governments do conclude exemptions or rebates are necessary, defining eligibility narrowly can help avoid applying the measures more broadly than absolutely necessary, thereby limiting the negative impact on environmental integrity and revenues.

A potential compromise is to choose design options that at least partially retain the emission reduction incentive. Tax-free thresholds that require entities to pay tax only on the portion of their emissions above the threshold, for example, partially retain the price signal, since liable entities are still encouraged to reduce the portion of their emissions that exceeds the threshold. Some revenue is also still raised in this case, though how much will depend on the level of the threshold and the amount by which entities reduce their emissions that exceed the threshold. Another option is to link exemptions or rebates to emission reduction measures (box 18). In these cases, effectiveness in encouraging emission reductions is naturally dependent on the stringency and effective implementation of agreements.

Exemptions and rebates are often used to address other policy objectives beyond addressing leakage and distributional concerns. For example, Mexico has exempted emissions from gas-powered electricity generation, aiming to further increase the incentive for shifting from coal to gas, beyond the incentive already built into the carbon tax, even though this will eliminate the incentive to switch from gas to renewables.

An alternative (or complementary) means of reducing the tax burden is by permitting liable entities to meet part of their compliance obligation through the use of offsets. This can reduce the compliance costs faced by entities while still ensuring the achievement of emission reductions. However, as in the case of exemptions, this results in reduced revenues. While it is common in carbon pricing systems that allow offsets to permit all entities to use them, some jurisdictions (e.g., South Africa) have set different offset use limits for different sectors, depending on their leakage exposure. The use of offsets is further discussed in section 8.2.3.

7.4.1.2 Support measures

In contrast to exemptions and rebates, support measures reduce the overall financial burden of entities subject to the carbon tax while leaving the price signal to reduce emissions unaffected. These support measures can take a number of forms:

- **Reducing (noncarbon) tax obligations.** One of the most common measures jurisdictions have taken to reduce the effects of the carbon tax on both industries and consumers is recycling the revenue through reductions in other taxes, such as corporate or labor taxes (chapter 8). Such reductions can target the economy as a whole through overall reductions in corporate or labor taxes, as happened in France, or by reducing health and social insurance contributions, as happened in Switzerland. Alternatively, they can more specifically target leakage-exposed sectors or vulnerable groups such as low-income families, as was done in Portugal.
- **Output-based rebates.** These are rebates provided to firms based on their level of output (i.e., units of goods produced), using an emissions benchmark established for the sector in question. The level of assistance is therefore raised as firms increase their output, directly protecting the firms against leakage. This approach has been applied in the context of the Swedish NO_x tax, while several emissions trading systems (ETSs) have applied a similar approach by providing output-based allocations.[38]
- **Supporting emission reduction actions.** Jurisdictions can also provide direct support to companies through subsidies[39] or technical assistance programs. These forms of support will often focus on encouraging the adoption of climate-smart technologies that reduce the cost of emission abatement while combining with the

[38] See further Partnership for Market Readiness, 2015 (section 5.3.3).

[39] Subsidies in this context may take a variety of forms, including grants, low-interest loans, and tax credits or rebates.

carbon price to provide a double incentive for reducing emissions. They may be targeted at households, as in the case of Ireland's Better Energy Warmer Homes Scheme; at businesses, as with Japan's incentives for energy-saving equipment for SMEs; or at both, as in the case of South Africa's energy efficiency tax credits for both companies and consumers

- **Flat payments.** These are direct financial transfers made to households or industry, often using carbon tax revenue. They are not linked to a given action on the part of the taxpayer. Examples of these are the various direct payments that were made to different vulnerable groups (including low-income households and the elderly) under the Australian Household Assistance Package, introduced alongside the Carbon Pricing Mechanism. Alternatively, assistance could be linked to the estimated additional electricity or heating costs low-income households are expected to face.

Since support measures reduce the overall financial burden on taxpaying entities while maintaining the price signal offered by the carbon tax, they are on the whole far more environmentally effective[40] than tax-reducing measures. In the case of mechanisms such as subsidies that support emission reductions, there may even be a double incentive, since taxpayers who avail of these programs will also reduce their carbon tax bill. Governments can also achieve net development benefits by implementing measures that benefit vulnerable groups and funding them through the carbon tax, which wealthier groups would likely disproportionately pay for.

On the other hand, it is important to keep in mind that support measures that are designed to maintain or even increase output levels—for example, output-based rebates—do not incentivize demand-side abatement, that is, reduce the consumption of carbon-intensive goods. Where a company's products would, in the absence of a given support measure, be substituted by a similar product from another jurisdiction, these measures are appropriate since otherwise leakage could ensue. On the other hand, where the increase in the cost of the product due to the carbon tax is likely to lead to substituting for other, less carbon-intensive options, an output-based rebate or similar approach may be counterproductive.

Well-designed support measures can be highly effective in avoiding unwanted effects of the carbon tax such as leakage and distributional risks. However, their effectiveness depends on their being well designed. Output-based rebates, for example, require appropriate benchmarks to be effective.[41] Flat payments or targeted tax reductions or incentives will be most effective when they are specifically designed to offset expected increases in expenses caused by the carbon tax, as was the case in Australia's Household Assistance Package. Where revenue is recycled through tax cuts, targeting cuts that lead to a net positive effect for many businesses and households can have a net positive economic impact and be politically popular—in British Columbia, this has been a key factor in gaining broad support from large parts of the business community for the carbon tax.[42]

Support measures can be costly for public budgets. In many cases, this is compensated by the generation of revenue from the carbon tax—whether or not tax revenue is formally earmarked or substituted. Overall, several studies have estimated the costs of support measures to be lower than those associated with exemptions.[43] They may also be more cost-effective in the long term, since taxpayers invest in emission reduction technologies, which may lead to increased competitiveness and lower costs, allowing support measures to be phased out. Jurisdictions use cost-benefit analyses to help determine the benefits—in terms of reduced leakage and distributional risks and overall economic effects—with the cost to the exchequer (see chapter 8 for detailed guidance on the economic effects of revenue recycling vs. other uses such as subsidies). Generally policy makers at least seek to ensure that financial support is only provided up to the point where the cost per dollar cost to the taxpayer is less than the benefit per dollar from supporting affected companies or households, and not beyond that point.[44]

Support measures will in some cases entail greater administrative costs than simple exemptions and rebates linked to carbon tax payments. Subsidy programs will typically require administrative capacity to assess and process applications and manage payments. Flat payments and tax reductions are generally more straightforward, but when designed to target specific groups of taxpayers, administrative capacity will be needed to clearly identify those groups and calculate assistance amounts. Output-based rebates, meanwhile, require the availability of up-to-date and high-quality data on average emission intensity in the jurisdiction in order to set benchmarks that accurately reflect average and/or best-practice emissions. They also require reliable and regular data on outputs to be reported.[45]

[40] Fischer and Fox, 2012.

[41] See Partnership for Market Readiness, 2015 (section 5.3.3).

[42] Personal communication with the British Columbia Ministry of Finance.

[43] See, for instance, Fischer and Fox, 2012.

[44] The cost per dollar to the taxpayer is equal to the total costs of providing a dollar of financial support. In addition to the financial support itself, this may include administrative costs, and should also take into account the "deadweight loss" associated with the collection of tax (chapter 8). The benefit per dollar of supporting companies refers to the total economic benefits of providing a dollar of support, such as the additional investment that is leveraged by providing a subsidy.

[45] Partnership for Market Readiness, 2015.

Jurisdictions will need to design subsidies and rebates in ways that ensure that they do not violate agreements the country is a party to under the World Trade Organization (WTO), in particular the Subsidies and Countervailing Measures Agreement. Specifically, a subsidy with "adverse effects" on the industry of another WTO member may open it up to legal challenge. Among other constraints, this means that subsidies or rebates should not be made contingent on export performance or the use of domestic inputs, nor be based on nonobjective criteria.[46]

7.4.2 Measures targeting leakage only

The following describes two additional types of measures that are designed specifically to address leakage.

7.4.2.1 Border measures and consumption-based taxation

The main strategy to effectively broaden the reach of the carbon tax is through the use of border carbon adjustments (BCAs). A range of BCAs have been discussed in the literature, though the most commonly proposed is a tax on certain imported goods from other jurisdictions that is equivalent to the tax paid on goods produced in the jurisdiction. An alternative form involves providing a rebate on exports, which helps ensure domestic firms do not lose market share in export markets. The level of the BCA would correspond to the carbon tax, ensuring that domestically produced products are not placed at a disadvantage relative to products from other jurisdictions.

While BCAs have been much discussed in the literature, there is little practical experience with their application in the context of carbon taxes,[47] though they have been applied to imported electricity in California's cap-and-trade system. They certainly have a number of theoretical advantages, including protecting against leakage without reducing the effect of the price signal on domestic industry, avoiding the strain placed on public budgets by exemptions and rebates, and counteracting the incentive of competing jurisdictions to gain a competitive advantage through "free riding," that is, abstaining from adopting climate mitigation policies. It can also provide an incentive for other jurisdictions to adopt a carbon price.

At the same time, the reluctance of jurisdictions to adopt BCAs so far reflects a number of political, practical, and legal challenges to their adoption. Politically, BCAs risk souring international relations with partners, fostering distrust, and triggering retaliatory measures. Economically, BCAs can harm sections of domestic industry that rely on imports for their production process by raising the cost of imports (by putting an additional tax on them), while on a practical level BCAs also raise challenges in design and administration. Last but not least, BCAs can be expected to generate legal challenges under international trade law, though a well-designed BCA may stand a good chance of being WTO-compliant (box 19)

An alternative to BCAs is to adopt a consumption-based tax on products that generally have high emissions embedded in their production processes. Such a tax would not be levied at the border, but at the moment of sale within the importing country. The tax rate here could be set based on the average GHG emissions emitted in producing the good in question. In many countries this is already the approach taken for administering a carbon tax on fossil fuels, though it has not been used for products that have GHG emissions embedded in their production Such a consumption-based tax would, by itself, likely be WTO-compatible, and potentially more politically acceptable as it fits in the established realm of domestic excise taxes.[48] At the same time, while it would incentivize demand-side mitigation (e.g., more efficient use or shift to cleaner products), by itself it would not incentivize cleaner production methods. To maintain incentives for producers to reduce their emissions, both domestic and foreign companies that can prove their emissions per unit of output lie below this average could then be entitled to a subsidy or rebate. Yet this subsidy or rebate would still need to be designed in accordance with WTO rules and would likely present significant administrative challenges.

7.4.2.2 Tax-coordinating measures

Countries can in principle avoid carbon leakage risks by ensuring that key competitor countries adopt similar measures to reduce GHG emissions from relevant sectors. There are no examples yet of countries or jurisdictions entering into reciprocity arrangements with regard to carbon tax, though several jurisdictions have linked their ETSs, which follows a similar logic by ensuring even carbon pricing across jurisdictions.

Reciprocity does not have to involve an identical carbon pricing policy having been adopted by all countries (e.g., all adopt a carbon tax), but rather equivalent policies that result in a similar price on carbon in the covered sectors. For example, if country A uses a carbon tax, country B uses an ETS, and country C uses traditional regulatory performance standards, this scenario can nonetheless serve a reciprocal function where the policies result in a similar cost of carbon, generated directly or indirectly, across the countries.

Reciprocity arrangements could be undertaken through a formal agreement (treaty) or through less formal political agreements. Though the latter would not be binding, they are probably easier to negotiate and countries would always have the option of introducing other measures, should their partners not stick to the agreement. To be

[46] Trachtman, 2016.

[47] There is some experience in applying analogous instruments to excise taxes such as those on tobacco and fuel.

[48] Trachtman, 2016

Box 19. Technical Note: BCAs – The Risk of a WTO Legal Challenge

BCAs involve the application of tariffs to imports, and so countries that are party to the treaties of the World Trade Organization (WTO) must comply with those treaties' provisions in designing a BCA. BCAs could potentially be challenged under a range of provisions under these agreements, including the "most-favored nation" and "national treatment" principles. As BCAs have not been litigated at the WTO level, it is not possible to determine with certainty how the WTO's Dispute Settlement Body would rule on such a policy. Consequently, there will always be the risk that even a well-designed BCA is held to be in violation of the treaties. Jurisdictions considering adoption of a BCA may nonetheless be able to increase the chances of compatibility by incorporating certain design features, for example:*

- If any kind of assistance is offered to domestic producers (e.g., exemptions, rebates, subsidies), importers should be offered equivalent assistance
- Imports from jurisdictions with comparable climate policies should be exempted from BCAs, and imports from jurisdictions with partially comparable climate policies should be partially exempted.
- The "embedded" emissions of imports should be calculated based on Best Available Technology benchmarks and importers should be given the opportunity to prove their contention that their production process emissions are lower than these benchmarks.
- So-called *de minimis* exemptions should be included for smaller quantities.

* *This text is provided for explanatory purposes only and should not be taken as legal advice. Jurisdictions considering the adoption of BCAs are advised to obtain legal counsel before proceeding.*

effective, a reciprocity arrangement would need to cover a sufficient portion of the trade in commodities deemed to be at risk of leakage, taking into account both the direct effects (i.e., direct tax obligations) and indirect effects (e.g., through electricity or fuel prices) on firms. This could be modeled on the "critical mass" approach used under plurilateral trade agreements, whereby agreements come into force once countries accounting for a given percentage of international trade in the covered commodities (e.g., 90 percent) become parties to the agreement.

Alternatively, in the case of products that are primarily traded regionally, jurisdictions may consider regional reciprocity agreements with major competitors to be sufficient. A special challenge arises when the jurisdictions involved have broad carbon taxes with uniform rates, but the trade-exposed sectors only constitute a fraction of the entities covered by the tax rate. Under these circumstances, the leakage risk for those sectors may not be sufficiently large for governments to want to let uniform rates agreed for those sectors determine their overall carbon price.

Key Considerations

- Though many jurisdictions remain very concerned about carbon leakage, to date there is little empirical evidence of carbon leakage actually having occurred in practice.
- Carbon taxes will in many cases have distributional impacts, but the nature of these impacts and whether they are assessed as positive or negative is very context-specific.
- Carbon pricing is designed to put certain carbon-intensive activities at a competitive disadvantage; where a carbon tax results in increased market share for less emissions-intensive firms, no leakage occurs, and this can in fact be considered a positive and intended outcome of the carbon tax.
- Carbon taxes that mostly target consumers will pose few leakage risks but may pose a greater risk of negative distributional impacts. The nature of these risks is highly context-dependent, and it is thus important to conduct specific risk assessments before deciding to act.
- Defining eligibility for mitigation measures that address carbon leakage or negative distributional impacts narrowly can avoid unduly compromising the effectiveness of the tax or burdening public budgets.
- What specific measures are chosen to address leakage or distributional risks can have important repercussions for the effectiveness of the tax. All else being equal, measures that retain the price signal of the tax will tend to be more environmentally effective.

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8 DETERMINING USE OF REVENUES

At a Glance

Carbon taxes can raise significant revenue. In many countries, even a modest tax of US$30 per metric ton of carbon dioxide equivalent (tCO_2e) emissions could raise revenue amounting to as much as 1–2 percent of Gross Domestic Product (GDP). Given the magnitude of the funds involved, it is important for policy makers to carefully consider how that revenue will be used. Decisions made in this context will have profound implications for the overall economy, the efficiency of the tax system, and public welfare.

Three basic strategies can guide the use of carbon tax revenue:

- **Revenue neutrality.** Revenue neutrality means that the government budget essentially remains unaffected. Any revenue from the carbon tax is either passed directly along or offset by reductions in other taxes. Revenue neutrality is generally achieved through one of two approaches:
  - **Rebates to households or businesses.** Redistributing revenue back to households, either on a per capita basis or directly to low-income households, is the simplest and most transparent form of revenue neutrality. Household rebates are often progressive and potentially politically popular because of their high visibility. Rebates can also be provided to businesses, as is the case with output-based rebates to address leakage.
  - **Reductions in other taxes.** Using revenue from the carbon tax to reduce other taxes often has the advantage of increasing the efficiency of the tax system, since carbon taxes typically have fewer inefficiencies and social costs than other taxes (e.g., labor taxes, capital taxes, and sales taxes). For that reason, this option is broadly considered the most economically efficient use of carbon tax revenue.
- **Increased spending.** Many jurisdictions have used carbon tax revenues to support government initiatives and pursue public policies. These are often climate-related policies (e.g., renewable energy subsidies or reverse auctions for emission reductions), but governments sometimes also choose to fund policies unrelated to climate change, including education, social programs, and investment incentives. Increased spending can benefit three main areas:
  - **General budget.** In many cases jurisdictions have moved the revenue directly into the general budget for unrestricted spending. In some cases governments have nonetheless agreed in broad principle how the new funds will be spent as guidance to government budget processes.
  - **Earmarks (hypothecation, ringfencing).** Some jurisdictions have employed earmarks to constrain the allocation of the new carbon tax revenue to specific uses. While this provides greater certainty that initial agreements about revenue use struck during the design process will be honored over time, it may also result in an inefficient allocation of resources.
  - **Debt reduction.** Jurisdictions can also spend the extra revenue on debt reduction. While this does not necessarily increase current spending, by paying down debt the jurisdiction can reduce the debt burden in future budgets.
  - **Forgoing revenue by permitting offsets.** Offset programs allow liable entities to fulfill (part of) their tax payment obligations by surrendering credits that correspond to emission reductions typically credited from outside the scope of the tax. Offsets can help contain the costs experienced by liable entities under the carbon tax and incentivize emission reductions outside the scope of the tax, but will lead to reduced revenues and potentially lower emission reductions in covered sectors. They can also be prone to environmental integrity concerns.

In practice, jurisdictions have employed all of these approaches and in many have combined multiple approaches according to policy needs and priorities.

8.1 INTRODUCTION

The question of how to use revenue generated by a carbon tax is a pivotal one that plays a role in how the new tax will affect the economy. The stakes could be quite high. For example, a national carbon tax of US$30 per tCO_2e in 2012 could have raised revenue of more than 1.5 percent of GDP in the United States and more than 2.5 percent in China (figure 19).[49]

There is no simple, universal solution to the question. To help policy makers examine options for the use of revenue, this chapter reviews three basic approaches and provides guidance on assessing each, applying the FASTER principles,[50] and weighing some context-specific considerations. Readers who want additional guidance on analyzing the potential economic effects of different revenue use options and interactions with other taxes can also refer to the discussion on the use of models in chapter 4.

The chapter is divided in two sections. Section 8.2 introduces the main options for revenue use and discusses their different implications and relative advantages and drawbacks. Section 8.3 compares the use of revenues in practice and sets out practical considerations for policy makers to take into account when determining how to use revenue.

[49] Parry, 2015.
[50] OECD and World Bank, 2015. For a discussion of the FASTER principles, see section 3.4 of this Guide.

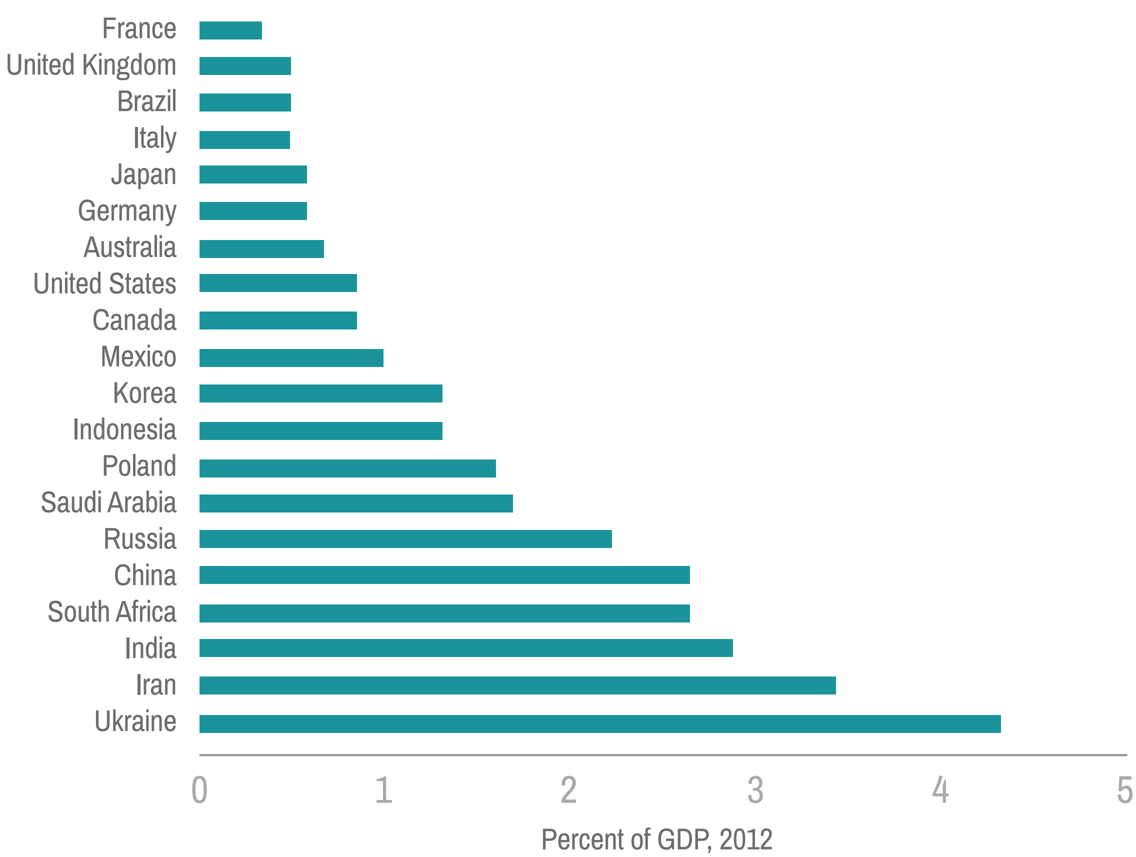
8.2 OPTIONS FOR REVENUE USE

Three main strategies can guide the use(s) of revenue from the carbon tax:

- Revenue neutrality
- Expanded spending
- Forgoing revenue by permitting offsets.

In practice, the lines between these three categories are not always solid and some approaches could be characterized by more than one strategy. Moreover, alternative approaches exist within these three categories. Finally, it is entirely possible to combine these approaches to suit local objectives and context. For example, revenue from the Danish carbon tax has been used to reduce taxes on labor, subsidize energy efficiency, and subsidize the administrative costs of small companies. Approximately

Figure 19. Revenue as a Percentage of GDP from a Hypothetical US$30 per tCO_2e Emissions in 2012



Source: Parry, 2015.

Note: GDP = Gross Domestic Product; tCO_2e = metric ton of carbon dioxide equivalent emissions.

Determining Use of Revenues

40 percent of the carbon tax revenue is used for environmental incentives while the remainder is returned to industry through reduced social insurance and pension contributions, and compensation of administrative expenses for small businesses with limited payrolls.

To guide policy makers, this section focuses on the three primary approaches, while distinguishing two broad options within the revenue-neutral strategy. It also highlights the relative advantages and limitations of the strategies.

8.2.1 Revenue neutrality

In the context of carbon taxes, revenue neutrality refers to those strategies where the taxes are collected, but not used to expand direct government spending. Of course, what constitutes *government spending* is a matter of interpretation. In this Guide, it is defined as "government payments for goods and services as well as repayment of debt" (section 8.2.3). Revenue neutrality involves jurisdictions either redistributing the revenue back to households or other recipients directly, or reducing other revenue streams to keep net government receipts unchanged. This section discusses each of these alternatives in turn.

8.2.1.1 Revenue neutrality by providing rebates

The first revenue-neutral approach is to return the revenue directly to citizens or taxpayers as a lump sum payment. For example, this could entail a system of periodic remittances in which individuals receive their pro rata share of the carbon tax revenue—a rebate.[51] This is also sometimes referred to as a "carbon dividend," and has been used in Switzerland, where roughly two-thirds of the revenue is redistributed to the public on a per capita basis through the health insurance system and reduced Old-Age Insurance System (OASI) social insurance contributions for businesses.

This approach has several advantages. Firstly, jurisdictions that adopt this approach establish a certain credibility with respect to the motivation for the carbon tax. It is clear that the government is not trying to extract additional revenue from taxpayers to expand its own budget or power. Rather, the primary purpose of the tax is to reduce fossil fuel use, increase energy efficiency, and mitigate carbon emissions. Moreover, of the many revenue use options, a simple per capita rebate is typically the most transparent. This aspect can be essential in building political support.

Secondly, this approach could also serve to redistribute income, depending on the design of the rebate. High-income individuals, who generally consume more energy per capita, might be expected to pay more in absolute terms than low-income individuals. If the rebate were to be distributed on a per capita basis, low-income individuals would receive more from the system of tax and rebate than they pay.

Jurisdictions that seek to further promote distributional interests can target rebates at low-income households, limiting payments to households below a specified income level. This was the approach adopted by Australia, where at least 50 percent of the revenues generated went toward a Household Assistance Package—financial assistance for pensioners and low-income households to compensate for the increase in the cost of living caused by the carbon price.

In the most extreme case, the revenue refund can effectively act as a top-up for welfare payments and low-income support programs. Targeting the payments at low-income households can be challenging however, as shown by the experience of Iran (box 20).

Thirdly, the option of using rebates is not limited to households. In some cases, governments have provided rebates to industries to counteract the burden of the new carbon tax or address identified leakage risks (chapter 7). If a jurisdiction provides rebates to businesses, however, it should carefully consider how to allocate the rebate. If the rebate is directly linked to the amount of carbon tax paid, it has the effect of dulling the incentive to reduce emissions. It would therefore be better for jurisdictions to link the rebate

[51] Shammin and Bullard 2009.

Box 20. Case Study: Iran and Budget Neutrality

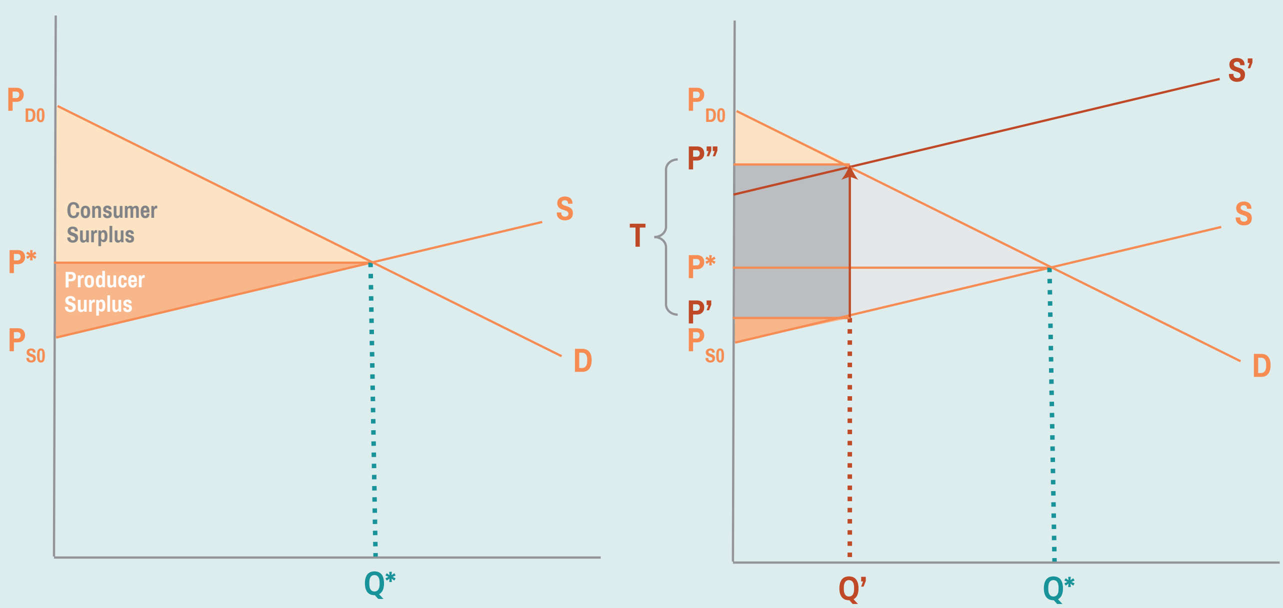
While Iran does not have a carbon tax, it has developed a comparable revenue-neutral energy pricing initiative that provides an interesting parallel. In 2010, Iran instituted the Targeted Subsidy Reform by which it substantially reduced its support for liquid fuel prices. The reform removed approximately US$50–60 million in subsidies. At the same time, the government provided unrestricted cash payments totaling about US$30 billion to households, and another US$10–15 to businesses for the financing of initiatives designed to reduce energy intensity. While the government initially intended to target the household payments at low-income families, it found that identifying those families was a very difficult administrative process. In the end, the government opted for per capita payments made without regard to income level. To build popular support for the initiative, which substantially raised energy prices, the government conducted a substantial public relations campaign, emphasizing the welfare gains from the reform and especially the benefits the cash payments would entail for low-income households.

Box 21. Technical Note: How Do General Taxes Lead to Social Costs?

Markets bring together buyers and sellers at a price that is determined by supply and demand, respectively. In the figure below (below, left), aggregate market demand and aggregate market supply result in a market price of P* and a quantity sold of Q*.

The demand curve comprises the aggregated demands of many different types of customers. Some of the consumers are willing to pay prices approaching PDO, but in fact only pay P* (below, left). Consumer surplus is generated when customers receive a good for a given price, but are willing to pay more than that price for the good. There is a corresponding producer surplus, which is the amount by which the revenue received by producers exceeds their costs of supply. Taken together, producer and consumer surplus are an indication of the net value the market brings to society, a concept known as *social surplus*.

Broadly speaking, taxes are applied to various activities such as investment, labor, land, and sales of goods and services to raise revenues for government use. When a tax, T, is applied to the supply of a good in the figure below (right), it has the effect of raising the supply curve from S to S'. This leads to a new higher market price P", an after-tax price to the producers of P', and a new quantity supplied of Q'. The consumer surplus shrinks, because the tax increases the market price the consumers face; the producer surplus shrinks because the tax decreases the after-tax price the producers receive; and both shrink because the quantity produced declines from Q to Q'. The dark gray shaded rectangle represents the amount of government revenue, equal to the product of T and Q'. The light gray shaded triangle is the value that is lost to society, also called the *Harberger Triangle*. The Harberger triangle is a measure of the deadweight loss, that is, the social cost incurred by deviations from the untaxed (undisturbed) market levels of production. The deadweight loss from taxes is realized not only in consumer markets like appliances, food, and clothing, but also in markets for factors of production such as capital, labor, and energy.



to other factors such as outputs (discussed in more detail in section 7.4).

The primary drawback of rebates is that they can be economically inefficient, and in some contexts extremely inefficient. As explained in box 21 and box 22, the social cost of raising government revenue—moving money from private pockets to government coffers—can be quite high. Jurisdictions are willing to incur these social costs because they attach much value to having public money for important investments in sectors such as education, health, and defense. Rebates essentially take a costly and high-value resource—government revenue—and convert it to a lower-valued resource—private resources. Compared with the options of government spending or lowering distortionary taxes (discussed in the next two sections), rebates will virtually always be less economically efficient.

8.2.1.2 Revenue neutrality by reducing non-carbon taxes

While providing rebates to households and businesses can be politically popular, it is not the only revenue-neutral approach. An arguably more economically efficient way to use the revenue is to reduce other taxes, also known as "tax recycling." Although the rationale for this approach is a bit more complex than that for rebates, many jurisdictions have found it compelling, and the approach has been applied broadly in jurisdictions such as British Columbia, France, Norway, Sweden, and South Africa.

When governments impose taxes, for example, on capital investment, this often causes a distortion in the price signals that make markets efficient (box 21), incurring a loss in social benefits. This means that when the government raises revenue by taxing economic activity, it often actually incurs a social cost that is higher than the nominal value of the tax. For example, based on the table in box 22, it costs the people of New Zealand $1.18 when the New Zealand government raises a dollar of revenue through a labor tax: $1.00 for the transferred resource and $0.18 dollars for the inefficiency caused by the ensuing price distortion.

The social cost of different taxes may also vary substantially across jurisdictions. For example, a recent study suggested that the marginal cost of labor taxes in the European Union ranged from €1.30 (Estonia) to €2.41 (France) (Barrios et al. 2013). In the former case, this means that for each euro of revenue raised by the government in Estonia via labor taxes, society incurred an additional loss of €0.30. In the case of France, as much as €1.41 of social welfare was lost for each euro raised by the government through labor taxes.

Even within a single jurisdiction, not all taxes result in the same level of distortion (or social cost) per unit of revenue (box 22). For example, it has been estimated that in Canada, the marginal cost of public funds raised via a tax on commodities is $1.25, while the marginal cost of public funds from a labor tax is in the range of $1.38 to $1.53.

Box 22. Technical Note: Are the Social Costs of All Taxes the Same?

While taxes can cause distortions leading to deadweight loss, not all taxes are equally distortionary. The extent to which a tax incurs deadweight loss depends significantly on the context. For example, taxes on goods and services with highly elastic demands will generally lead to greater deadweight loss because there will be greater adjustments in quantity (see discussion of elasticities in section 2.3.2). Higher taxes also result in higher distortion and higher levels of deadweight loss. By this principle, when the government adds additional taxes onto preexisting taxes, it leads to greater deadweight loss per unit of additional revenue.

The existence of this deadweight loss from taxation means that moving a dollar of resources from private to public coffers generally costs society more than a dollar—sometimes even significantly more. Estimates provided in the table to the right highlight three points in this regard. First, estimates of the costs of public funds depend on the source of the revenue. Some taxes can be more distortionary than others. Second, the cost of public funds can vary from one country to another. Third, and perhaps most importantly, estimating the marginal cost of public funds—the extent to which taxes cause deadweight loss—can be very difficult. In the table to the right, the estimates of the marginal cost of public funds vary significantly across studies, even for the same country and tax source.

Estimates of Marginal Cost of Public Funds

COUNTRY	TAX INSTRUMENT	ESTIMATE
Australia	Labor	1.19-1.24
	Labor	1.28-1.55
	Capital	1.21-1.48
	Capital	1.15-1.51
Bangladesh	Sales	0.95-1.07
	Imports	1.17-2.18
Cameroon	Sales	0.48-0.96
	Imports	1.05-1.37
Canada	Commodities	1.25
	Labor	1.38
	Labor	1.39-1.53
China	Sales	2.31
India	Excise	1.66-2.15
	Sales	1.59-2.12
	Imports	1.54-2.17
Indonesia	Sales	0.97-1.11
	Imports	0.99-1.18
New Zealand	Labor	1.18
Switzerland	All taxes	1.69-2.29
United States	All taxes	1.17-1.56
	Labor	1.21-1.24
	Labor	1.32-1.47
	All taxes	1.47
	Labor	1.08-1.14
	All taxes	2.65
	All taxes	1.23
	All taxes	1.07
	All taxes	1.18

Source: Chisari and Cicowiez 2010.

Note: The estimates above are based on ratios relative to a given currency unit, and so apply regardless of the currency of the jurisdiction

Box 23. Technical Note: Can Carbon Taxes Reduce the Social Costs of Raising Revenue?

Some studies suggest that because of the distortionary effect of taxes on capital, labor, and other resources, environmental taxes such as carbon taxes can provide a "double dividend," where the revenue is recycled to reduce those existing, "traditional" taxes. The first dividend refers to the ability to reduce GHG emissions; the second dividend refers to the reductions in deadweight loss caused by the associated tax cuts. Such a tax reform can in principle reduce the overall social cost of raising government revenue by shifting away from potentially more distortionary taxes on resources such as labor and especially capital (which are often more elastic and already subject to very high taxes) to taxes that are potentially less distortionary (such as those on energy).

To what extent the double dividend hypothesis plays out in practice is subject to debate. While the use of carbon tax revenues to reduce distortionary taxes clearly brings benefits—referred to as the *revenue recycling effect*—other effects lead to offsetting losses, or *tax interaction effects*. An example of a tax interaction effect would be a rise in the price of energy caused by the cost of the carbon tax, which could lead to a loss of jobs and a decrease in investment levels. Thus, it is not clear whether the double dividend is the norm.

Regardless of whether a carbon tax brings a double dividend, there is broad agreement that where governments decide to regulate pollution, using revenue-raising instruments such as carbon taxes (or auctioned marketable allowances) is generally more efficient than using an approach that does not raise revenues. This is because the non-revenue raising instruments also induce all of the negative tax interaction effects, without entailing the benefits of the revenue recycling effect.

The difference in marginal cost of public funds across types of taxes means that some jurisdictions may have an opportunity to maintain the government's level of revenue while incurring a lower overall social cost. For example, it has been reported that in Slovakia the marginal cost of public funds from labor taxes is €2.19 whereas the marginal cost from green taxes (largely energy taxes) is only €1.06 (Barrios et al. 2013). This suggests that even as the country maintains its current level of government revenue, Slovakia could actually reduce the cost of raising government revenue by lowering its labor taxes and raising its green taxes, essentially shifting from more distortionary taxes to less distortionary taxes.

When a government taps a substantial new source of revenue, as may be the case when adopting a new carbon tax, it could use this revenue to reduce the use of the most distortionary taxes. This option has given rise to the "double dividend" hypothesis, which suggests that jurisdictions could actually reduce the social cost of their public finance systems by shifting taxes from factors that provide positive inputs to society (e.g., labor, capital, and goods and services) to those that result in overall harm to society (e.g., emissions) (box 23). This suggests that jurisdictions would be economically better off, even if they do not take into account the environmental gains derived from the tax.

The merits of the double dividend hypothesis have been vigorously debated in the economic literature. However, one clear conclusion is that if jurisdictions are going to regulate the level of carbon emissions, it is economically efficient to use revenue-raising mechanisms such as a carbon tax or an ETS with auctioning, because they impose no additional distortions. Under this scenario, it becomes possible to reduce the most distortionary taxes (e.g., taxes on capital and labor) and still maintain the same level of revenue.

There may be additional reasons to substitute a carbon tax for other taxes. Carbon taxes can be more difficult to evade than other forms of taxation because they often fall on very easy to observe, highly controlled goods like oil, gas, and coal, or on highly regulated industries such as the electricity-generation industry. These beneficial properties can lead to net decreases in the amount of tax evasion when a carbon tax is levied, compared with other forms of taxation (Liu 2013).

Carbon taxes can also influence the size and composition of the informal economy (Bento et al. 2016). The informal sector consists of the set of activities that occur outside the regulation, protection, and control of the state. Some kinds of taxes, like those on labor and capital, have been shown to cause increases in the size of the informal economy, creating further opportunities for tax evasion. Carbon taxes, by contrast, are typically more difficult to avoid, even for the informal sector. This is because even the informal sector must purchase electricity, gasoline, and heat through government-regulated firms, though in some jurisdictions substantial informal markets may exist for domestic commodities such as motor fuels and coal.

Carbon taxes can also be better than other taxes where they act as an indirect tax on resources such as oil and natural gas. Taxing labor and capital can cause workers and investors to move activities outside the taxing jurisdiction. This leads to an inefficient reallocation of resources. But oil reserves, coal mines, and natural gas wells cannot be

Box 24. Technical Note: Are Carbon Taxes Stable Sources of Revenue?

One possible use of carbon tax revenue is to put it directly in the general treasury, either to allow reductions in other taxes or to pay for additional services. However ,some jurisdictions prefer not to rely on revenue from a carbon tax as part of their budgeting process because doing so means the revenue source will decline over time, assuming one of the objectives of the tax is to reduce emissions. This is an important concern that deserves closer consideration.

To provide additional insight into this point, policy makers can consider conducting additional analyses, employing one or more of the dynamic modeling techniques described in chapter 10.

It is worth noting, however, that where the carbon tax works through fossil fuels, as consumption goes down, tax revenues can go up. In most economies, the elasticity of demand for fossil fuels is inelastic (see section 2.3.2 for more details on elasticities of demand). This means that as the price of a good rises, the overall amount spent on that good also rises.

To illustrate this point, imagine a jurisdiction where the price of auto fuel is US$1.00 per liter, the elasticity of demand equals 0.50, and the consumption is one million liters. Spending on fuel would be US$1.0 million. If the jurisdiction instituted a carbon tax that effectively increased the price of fuel by US$0.10 per liter (that is, a 10 percent increase), the reduction in fuel use would be of approximately 5 percent, to 0.95 million liters. The tax revenue would be roughly US$95,000. The jurisdiction then, seeking to further decrease fuel consumption, raises the tax by another US$0.10 per liter. If the elasticity remains roughly the same, consumption will decrease to approximately 0.9025 million liters and revenue from the carbon tax will rise to about US$180,500.

This calculation illustrates that the dynamics of tax revenues are complex. This example assumes that the elasticity of demand is constant over the relevant range. Moreover, it assumes no technological breakthroughs occur that fundamentally change the demand for energy. Policy makers may want to conduct their analysis with different assumptions about future responses and technology developments.

moved, so taxing them does not lead to inefficient flight. Thus, generally, when immobile resources like these are taxed, less distortion and deadweight loss results than when labor or capital are taxed. If the government is not already fully taxing those immobile resources, the carbon tax provides an opportunity to do so (Bento and Jacobsen 2007).

While there are several economic efficiency advantages to recycling the revenue from a carbon tax to reduce other taxes, the decision regarding which taxes to reduce has implications beyond efficiency. In some jurisdictions, the most distortionary taxes, say those on capital, are also the most progressive. While cutting these taxes might entail the greatest economic efficiency gains, those gains

Box 25. Case Study: British Columbia and the Revenue-Neutral Approach

Each year, the Ministry of Finance is required to submit a three-year plan for recycling revenue from the carbon tax to households and businesses to ensure the carbon tax is revenue- neutral. If the Minister fails to fully recycle the revenue, he/she may be assessed a personal penalty, in the form of a 15 percent salary reduction (Duff, 2008, 99).

Current personal tax reductions include the Low Income Climate Action Tax Credit, which reduces the first two personal income tax rates by 5 percent. Northern and rural homeowners, seniors undergoing home renovation projects, children's fitness and art programs, small business venture capital programs, and training programs also benefit from personal tax reductions.

Business tax reductions have included general corporate income tax rate reductions, an increase in the corporate income tax small business threshold, and industrial property tax credits for school property taxes payable by major industry (British Columbia Ministry of Finance, 2013).

The revenue-neutral aspect has been key to gaining broad public and industry support for the carbon tax. Indeed, many businesses have even called for further raises in the carbon tax, since this can be expected to lead to tax decreases elsewhere. This outcome was also helped by taking a highly transparent approach to revenue recycling, with the Ministry of Finance required to submit plans each year to communicate to the legislature how the revenues are intended to be used.

could be distributed disproportionately toward wealthier segments of society. If this were to happen, it might make this measure inconsistent with other policy goals, such as enhancing equality and combatting poverty.

Governments might then want to seek to reduce taxes that are both regressive and distortionary such as payroll and value added taxes (VATs). In small jurisdictions with open economies, where returns on capital are determined by international markets, even corporate income taxes may in effect ultimately be borne by labor in the form of wage decreases, due to the high sensitivity and mobility of capital. A number of adjustments may also be made to the tax system, such as cutting particular tax preferences for the wealthy, which could be instituted simultaneously with cuts in more distortionary taxes to make the package of adjustments less regressive.

Policy makers in most jurisdictions that consider recycling revenues face a trade-off between efficiency and fairness as they decide how to use the new carbon tax revenues. This, however, is little different from the dilemma governments regularly face in any tax design situation.

One risk of using carbon tax revenues to maintain revenue neutrality while reducing distortionary taxes is that it may lead to unstable government revenue streams as the economy shifts to low-carbon alternatives. This is a real concern if a jurisdiction has an elastic demand for fossil fuels, though less so in jurisdictions where demand is inelastic. As discussed in box 24, the fact that fossil fuel consumption in most economies is not highly responsive to increases in price (at least in the short run) means that while carbon emissions will go down as taxes rise, revenue will generally rise because the tax rate will often rise faster than the emissions will fall (as a result of the inelastic fossil fuel demand).

Another potential disadvantage of tax recycling is that the concept of using new revenue to reduce distortionary taxes and thereby improve the economy acts more indirectly to create benefits than some of the other approaches. It is a more complex concept and thus may be difficult for many citizens to understand. Consequently, it may be difficult for jurisdictions to gain political support for the initiative, even when it leads to significant gains in economic welfare. Governments can boost this support by ensuring transparency on the use of revenue (see box 25 on the experience with a revenue-neutral carbon tax in British Columbia). Revenue recycling may also be less popular for political reasons, because of the perception that the richest companies and individuals typically benefit the most from tax reductions.

8.2.2 Expanded public spending

The main alternative to revenue recycling is to use carbon tax revenues to expand government spending. For example, jurisdictions with strong renewable energy and energy conservation interests have opted to use their carbon tax revenue to subsidize programs in those fields, such as in India and Denmark. Box 26 illustrates a variety of approaches jurisdictions have taken in practice.

Generally, jurisdictions have directed funds to various types of spending by increasing the general budget, through earmarks, or through debt reduction. Each of these options is considered below.

8.2.2.1 General budget

Jurisdictions might choose to view carbon tax revenue as simply another source of income, akin to labor, sales, or capital taxes. In this case, the taxes are sent directly to the general budget to be drawn up as part of the general budgeting process. The fact that carbon taxes are a new source of revenue allows government spending to expand. Many jurisdictions prefer this approach for efficiency reasons—each potential use of revenue is forced to compete with all others rather than being afforded special treatment.

In many jurisdictions, all tax revenue is legally required to be deposited in the general budget, and so it is not permitted to make a specific connection between a given revenue source and a given revenue use. This is the case, for example, in the United Kingdom, Mexico, and South Africa. Such jurisdictions may still decide to provide allocations from the general budget for certain purposes that might not have been possible without the income generated by the carbon tax.

8.2.2.2 Earmarks

Also referred to as "hypothecation" or "ringfencing," tax earmarking involves dedicating the revenue from a particular tax stream to a specific purpose. Governments may earmark revenue for a variety of purposes, including:

- **Environmental.** Some countries have earmarked their revenues for various investments to build the infrastructure and technologies required for a low-carbon economy. This approach has been taken in India and Japan.
- **Tax-affected groups.** Earmarking for groups affected by the carbon tax, for instance, financial assistance to communities negatively affected by tax. Most jurisdictions that have adopted this approach have focused the assistance on supporting energy savings by low-income groups, as France has done.[52]
- **Environmentally affected groups.** Climate change will affect some groups more heavily so jurisdictions could opt to dedicate some of the carbon tax revenue

[52] Other countries such as Ireland have also introduced assistance programs for low-income households to improve their energy efficiency, though this has been funded through the general budget.

Box 26. Contrasts in Revenue Use

Even among jurisdictions that have opted to use the revenue from a carbon tax to fund government initiatives, there is substantial variation.

- In India, the revenues raised through the Clean Environment Cess go toward the National Clean Energy Fund to finance clean energy initiatives, environmental remediation, and research on clean energy technologies. Individuals and organizations in the public and private sector can apply for funding for projects that are related to clean fossil energy, renewable/alternative energy, energy infrastructure, or installation of energy-efficient technology. Moreover, the project must be sponsored by a government department, must be self-funded by the recipient individual/organization by at least 40 percent, and must not have received funding from another government agency.
- In Japan, tax revenues are to be used to promote low-carbon technologies, energy efficiency improvements, and renewable energy.
- In Ireland, the tax revenues are being directed to the general budget to allow for flexibility in use. Although the carbon tax was originally intended to be revenue-neutral, the government has not been able to use the revenues to decrease labor taxes, given the significant public deficit. However, it appears the revenues from the carbon tax have prevented additional increases in labor taxes.
- In France, the carbon tax is designed to be revenue-neutral, with reductions in other taxes. Reports have suggested the government plans to use at least a portion of the revenue to reduce corporate income taxes and provide energy assistance to low-income individuals. However, recently, the French government indicated a significant portion of the revenues is now used to decrease labor taxes through the "tax credit for encouraging competitiveness and jobs."
- In Iceland, carbon tax revenues simply go to the general budget.
- Currently, in Mexico, all revenue is directed toward the general budget. Although in principle it is possible for Congress to provide for all or part of the revenue to be directed toward a specific cause, earmarking is generally not favored in Mexico because of legal aspects of the national tax structure.
- In Norway, carbon tax revenues from the petroleum industry go to the Global Government Pension Fund—to contribute to the government savings needed for the financing of the rising public pension expenditures and to support long-term priorities for the spending of government petroleum revenues. Other revenues from the carbon tax have generally gone to the national budget.
- In Chile, taxes are paid to the general budget. It has been proposed that the largest share of the revenues be spent on improvements to the education system.
- Denmark has taken a mixed approach to revenue use. Revenue from the carbon tax has been used to reduce taxes on labor, subsidize energy efficiency investments, and subsidize the associated administrative costs of small companies. Approximately 40 percent of the tax revenue is used for environmental incentives, while the remaining 60 percent is returned to industry through reduced social insurance, reduced pension contributions, and compensation of administrative expenses for small businesses with limited payrolls.

Full descriptions and references may be found in the technical appendix to this Guide.

to this purpose. To date, Catalonia, which provides funding for citizens who experience negative health effects and suffer from extreme weather impacts, is the only jurisdiction to have decided to use (part of) the carbon pricing revenue in this way.

This list is not exhaustive or mutually exclusive. It is common for jurisdictions to use the tax revenue for a number of purposes rather than just one.

Not all spending applications are strictly carried out through either general budgeting or earmarking. For example, in the case of the Chilean carbon tax, the government expects to collect roughly US$160 million from the carbon tax and roughly US$8.3 billion in revenue from a broader tax reform. Taxes are paid to the General Treasury and it has been proposed that revenues be spent on improvements to the education and health systems, and several other programs (Szabo 2015). While this is not an earmarking approach, since the government has not established a separate fund dedicated to a particular purpose, it is clear that the revenue from the carbon tax is used to help the government fund education and health initiatives.

Box 27. Case Study: Ireland Carbon Tax – Used to Raise Money to Repay National Debt Arising from Financial Crisis

In September 2008, in the wake of the global financial crisis, the Irish government issued a broad state guarantee of the debts of Irish banks. As debts rose to €64 billion and the public exchequer struggled to meet the rising obligations, Ireland was forced to enter into a bailout program with the European Central Bank, the European Commission, and the International Monetary Fund (known as the "Troika") in November 2010. Those organizations collectively provided financial support in exchange for the implementation of a number of revenue-raising measures. Under this program, the introduction of a carbon tax, which had already been agreed in principle in 2007, was expedited. Between 2010 and 2012, the carbon tax contributed between 21.5 and 24.6 percent of the tax increases required by the Troika (Coverny et al. 2014).

Earmarking achieves several government objectives:

- Ensuring that the carbon tax and its revenue are used for related purposes. Some governments are obliged by law to satisfy this condition. For example, in California, it has been argued that a California referendum (Proposition 218) requires that any revenue raised by an environmental tax or charge must be dedicated to protecting, restoring, or managing the environment. Hence, under a subsequent law, California uses revenue from its emissions trading program auctions to fund environmental programs, primarily in the area of air quality (California Assembly Bill 1532). Even where not required by law, using the revenue for related purposes may help make different aspects of a government's climate policy mutually supportive, and help it gain public support in jurisdictions that strongly support climate action.
- Linking the magnitude of the funding to the magnitude of the problem. The underlying logic is that as the severity of the problem declines, so too will the revenue raised by taxing it, leading to proportionality between the need for funds and their availability. For example, some jurisdictions might dedicate the carbon tax revenue to developing renewable energy supplies. If that approach works, in terms of spreading the use of renewable energy and reducing carbon emissions substantially, the carbon tax revenue might also decrease, coinciding with a decrease in the original need for the revenue.
- Earmarking avoids the budget process. By dedicating funds from carbon taxes to preferred projects and programs, the government can avoid periodic budget reviews and the attendant uncertainty.

Like some of the revenue-neutral options, earmarking can also be used to gain political support from specific interest groups. In this case, the incentive comes in the form of in-kind payments or beneficial programs rather than direct payments or tax benefits.

While earmarking has some advantages over alternative approaches to spending, generally speaking it removes revenue use from competing with broader goals in the budget process. Thus, it will decrease a government's capacity to align its objectives when compared to an approach that directs revenue to the general budget.

In addition, earmarking revenue can commit a government to a particular use over many years. However, this can be inefficient, as technology and markets are typically too fast and efficient for relatively slow legislative processes to earmark money efficiently. Moreover, where governance is weak, allowing earmarks may create opportunities for particular interest groups to increase their control of funding decisions.

Some argue that earmarking generally does not improve public spending decisions and leads to less effective spending than using the funds to augment the general budget. This is because there is a tendency to view the new funds as "free money," and not to question the cost-effectiveness of the programs to which the funds are dedicated. Earmarking for a particular application (e.g., environmental protection) can also lead to insufficient resources for that application if the government budget process responds to the earmark by cutting other budgeted funds for the application. More directly, if the carbon tax is repealed, the program receiving the earmarks loses its funding source, regardless of the merits of the program itself.

An alternative argument in favor of earmarking is that setting the carbon tax revenue aside for environmental and low-carbon applications will lead to more certain environmental protection. While this is true, it presumes that environmental integrity is a higher priority for spending than other social objectives such as education, health, and economic development.

8.2.2.3 Debt reduction

Revenue can be used to help pay down national debt, which can also have a positive impact on the economy (box 27). Some jurisdictions have chosen this approach, as it has broad political appeal and leads to decreased government debt payment obligations over time. Thus, even if the revenue stream declines over time, the benefits of reduced debt are spread over many years.

8.2.3 Forgoing tax revenue to finance offsets

Jurisdictions may decide to allow liable entities to compensate part of their tax obligations with surrendering offsets. In doing so, the government forgoes a certain amount of revenue that would otherwise be generated through tax payments. There is significant experience with using offsets in the context of ETSs, though jurisdictions have only recently begun to permit their use under carbon tax programs. This section explains the main considerations that are relevant to determining whether to include offsets in a tax program, beginning with defining offsets and discussing the specifics of their use in tax programs. It goes on to discuss the benefits and drawbacks of including offsets, and highlights policies and national circumstances that affect this decision.

8.2.3.1 What is an offset?

Offsets are credits representing emission reductions (or removals) that have taken place outside of the scope of the carbon tax and have been verified in accordance with a recognized offset standard. Offsets are usually generated under so-called "baseline and credit" projects or programs, whereby emissions are measured in accordance with criteria established by the offsets standard—against the predicted level of emissions in the absence of the project or program (known as a "baseline"). Offsets are typically issued for the quantity of emissions reduced or sequestered (e.g., in forest enhancement projects), and are measured in terms of tons of carbon dioxide equivalent (tCO_2e), which represents the difference between the baseline and actual emissions.

The primary purpose of offsets is to substitute liabilities for reducing emissions under compulsory carbon pricing schemes, in particular ETSs or carbon taxes. The surrender of an offset will typically entitle the liable entity to reduce its liability—surrendering emissions units or paying a carbon tax—by the same amount.[53] Offsets are also used to satisfy international mitigation commitments—such as those under the Kyoto Protocol and the Paris Agreement—and to meet voluntary mitigation commitments or for voluntary offsetting of emissions by companies or individuals.

An alternative to offsets that has been used under some carbon tax programs involves permitting liable entities to reduce their tax obligations by entering into agreements with the government under which they reduce their emissions. These programs share several characteristics with offsets, since they seek to reduce tax obligations while still achieving emission reductions. Since they are mostly considered in the context of avoiding carbon leakage, they are discussed in section 7.4.1.

8.2.3.2 Offsets in the context of a tax program

Offsets are less common in carbon tax programs than under ETSs. The Mexican carbon tax is the only existing system that permits offset use and is still in the process of designing the modalities for how this will work, although the former Australian Carbon Pricing Mechanism also made provision for offset use. South Africa has also provided for the use of offsets in its draft Carbon Tax Bill, and has published draft regulations to guide this; both of these instruments are currently under revision, following consultations. Switzerland does not allow offsets for carbon tax compliance, but allows companies to join the ETS instead of paying the carbon tax, where they can then use offsets toward their compliance obligations.[54]

There is, therefore, still very little practical experience with the use of offsets in the context of tax programs. The main experience with offsets is, rather, drawn from their use under international emissions trading and domestic ETSs. This experience can inform many of the issues that arise when considering offsets in a tax program. For instance, the process of establishing offset programs is broadly the same, whether the program will feed offsets into an ETS or a carbon tax, with issues such as additionality and ensuring robust methodologies and verification processes remaining key. Moreover, the core motivation for permitting offsets—reducing the costs of compliance for covered entities—is also the same. These issues are discussed in depth in the PMR ETS Handbook (PMR & ICAP, 2016) and are not repeated here.

On the other hand, a number of issues more specific to the use of offsets under a carbon tax are important to consider.

First, *allowing the use of offsets will lead to reduced revenues*, since covered entities can surrender offsets in lieu of paying taxes. Deciding whether to permit offsets should therefore be considered in the context of decisions on the use of revenue. To the extent that international offsets are permitted and used, the forgone revenue is essentially lost from the economy, though the country receives a benefit to the extent that it can use those offsets toward its international mitigation contributions. On the other hand, where domestic offsets are used, the forgone revenue can be considered an investment in reducing emissions in the sectors from which offsets are permitted, which are typically not covered by the carbon tax.

[53] In an alternative design, jurisdictions may also determine that an offset has a lower value, for example, requiring that two offsets be surrendered to reduce one tCO_2e in liability under the ETS or carbon tax.

[54] The motor industry is also obliged to surrender offsets to cover 10 percent of its emissions annually.

The effect of this is comparable to that under earmarking, since funds are diverted from the general budget to a specific objective, in this case, reducing emissions in uncovered sectors. There is an important difference, however. While, with earmarking, the amount of money that is diverted to a given objective is exactly equivalent to the revenue forgone from the general budget, with offsets this is not necessarily the case: the actual amount of money invested in emission reduction projects will depend on a range of factors, such as:

- **Type of offsets permitted.** Whether allowing the use of offsets results in new investments in emission reduction projects depends on whether the rules on offset use are designed so as to encourage such investment. On the one hand, this requires robust rules on additionality of credits, so that jurisdictions ensure only offsets from projects that would not have occurred in the absence of the carbon incentive are allowed. In this case it is even possible that the finance raised through offset generation can leverage a significant amount of additional investment that would not otherwise have been made. On the other hand, it means jurisdictions should consider restrictions on the use of credits generated or projects registered before the carbon tax or a given date prior to the carbon tax, in particular if they estimate that these credits would have been generated regardless of the demand created by the carbon tax. This latter consideration is particularly important where there is a large surplus of offset credits on the market, as is the case, for example, with the global supply of credits from the Clean Development Mechanism (CDM)—though this may be different at the national or jurisdictional level.

- **Cost of emission reductions.** As discussed in chapter 4, the cost of achieving emission reductions varies significantly across sectors and activities, and so will therefore the amount of money invested in achieving them. One of the chief advantages of offsets is that the market seeks out the lowest-cost reductions. On the other hand, investors will generally only invest where the cost of producing the offset is less than the carbon tax rate. Where achieving emission reductions is very cheap and there is a significant demand for offsets, bringing the price close to the tax rate, offset providers may make substantial profits, and governments may forgo substantial revenue for little investment. In this case, earmarking or the design of government purchase programs for low-cost offsets may be a more attractive option.

- **Market price.** In the case that the carbon tax provides the only or main source of demand, a market for offset credits can be expected to develop. The market price will in general not be higher than the carbon tax rate, as otherwise participants would simply pay the tax rate rather than use offsets.[55] In the event of scarcity of offsets or high offset costs, the market price may move closer to the tax rate and there may be little incentive to purchase offsets. How responsive the offset market is to fluctuations in demand will to some extent determine its usefulness as a cost-containment tool.

- **Transaction costs.** The process of generating offsets requires substantial time and effort not only in generating emission reductions, but also in developing and applying methodologies, measuring, reporting, and verifying emission reductions, and in issuing and transferring the offset units. Many of these steps will typically require project developers to invest significant time and hire external consultants, often incurring substantial costs. While efforts by liable entities to reduce their emissions (i.e., to reduce tax liability) will generally involve transaction costs regarding seeking out opportunities, monitoring and evaluation (M&E), etc., the use offsets entails a range of additional costs that would not otherwise be incurred. This may result in the actual costs of offsets being significantly higher than the cost of the underlying emission reductions, reducing the efficiency of the revenue use as a tool to reduce emissions. It is worth noting that earmarking revenue for low-carbon incentives will also entail a certain amount of administration and transactions costs (PMR & FCPF 2016).

A second important consideration is that, while an ETS is itself a market-based instrument that by definition includes a full trading and registry infrastructure, a carbon tax does not and will therefore need to develop this infrastructure, especially for the purpose of offset use. At a minimum, this will include a registry system that serves to store, cancel, and retire carbon offsets. Such a system will need to be sufficiently sophisticated to enable it to accurately differentiate and track offsets so as to avoid double counting,[56] and must be sufficiently secure to protect against theft and fraud. The responsibility for the development and operation of the registry itself can be assumed domestically or outsourced to one of several existing registry platforms. In either case, it will

[55] An exception to this is where offsets can be banked (used in the future). In this case, prices may reflect future tax rates as well. Thus, if the tax rate increases at a faster rate than the market discount rate, the offset price could move above the tax rate at a given moment.

[56] *Double counting* involves the use of the same emission reduction more than once toward an emission goal or target. It can arise in a variety of forms, for instance, through the same project being registered under two different offset standards or two different projects claiming the same emission reduction. Improperly functioning registries can also lead to double counting, for example, where a unit is duplicated in a given registry or transferred twice, or if a unit is used toward a mitigation contribution but not subsequently retired.

Box 28. Case Study: Offsets in the Mexico Carbon Tax

Under the Mexican carbon tax, companies will be allowed to substitute the payment of tax obligations by surrendering CDM credits (Certified Emission Reductions or CERs) from Mexican projects. The value of offsets for purposes of substituting for carbon tax obligations will be determined according to the monetary value of CERs purchased, not the *carbon value*. It is not clear yet how this will work in practice, though one option under consideration is taking the international market price on the day of surrender as the value of the credit. This system will be launched in 2017.

The potential advantage of using the monetary value of credits to determine their worth in terms of substituting tax obligations is that it avoids the scenario of an oversupply of credits undermining the disincentive to emit, established by the tax, and discourages offsets targeting very cheap emission reductions. On the other hand, the approach limits the opportunity for offset developers and intermediaries to make profits, which may discourage the development of a strong and dynamic market.

be necessary to develop laws and regulations that govern the functioning of the registry and the accounting process for offset use.

If jurisdictions seek to have a dynamic and well-functioning market, they may also want to establish or designate a trading platform and infrastructure. While this will already be a fundamental part of ETSs, this is not the case of carbon taxes, and jurisdictions that do not already have functioning offsets markets may need to consider developing these systems from scratch, adding an additional cost.

All these tasks involve—sometimes substantial—costs, which should be taken into account when considering offset use.[57] At the same time, offset schemes can build in fees for participation or credit issuance, which can compensate for public expenditures. These systems can also help build capacities and provide the basis for future trading schemes where the jurisdiction has a long-term goal to implement emissions trading.

8.2.3.3 Determining whether to include offsets in a tax program

There are a number of potential benefits and drawbacks to permitting the use of offsets in a carbon tax program, and the decision will inevitably involve a number of trade-offs. Table 23 compares some of the main considerations on each side.

8.2.3.4 National circumstances and policy objectives

When considering whether to allow the use of offsets in the carbon tax program, jurisdictions will need to take into account their broader national context and climate policy objectives. Among the most relevant of these considerations are the following:

- **Climate policy mix.** The existing and planned climate policy mix is a crucial factor. Where few climate mitigation incentives exist or are planned in sectors not covered by the carbon tax, providing for (domestically generated) offset use can be a good way to encourage emission reductions in these sectors. On the other hand, if the objective is to seek maximum emission reductions in covered sectors, offsets can disrupt this goal.
- **Conditions for offset market.** Policy makers should consider whether a functioning offset market already exists in the country (e.g., existing projects, involvement of private sector in offset trading). If not, it is worthwhile to consider why this market failed to develop, and if there are certain factors that would prevent offset trading from operating successfully with respect to the carbon tax scheme.
- **Capacities and reduction opportunities.** Jurisdictions wishing to establish an independent offset system will need to have strong institutional capacities and should consider whether there are sufficient suitable emission reduction opportunities as well as private sector capacities in sectors that would be covered by the offset program in order for it to be feasible.

8.3 REVENUE USE IN PRACTICE

As illustrated by table 24, jurisdictions have adopted a very wide range of practices regarding carbon tax revenue use. In most cases, jurisdictions have opted to allocate funding to multiple uses, often spanning the different categories of revenue use discussed in this chapter. This reflects the various strengths and weaknesses of the different options, and the fact that governments will typically have multiple policy goals they want to support through revenue use. It also reflects the practical side of carbon tax adoption—revenue use strategies can be a powerful tool for gaining

[57] These issues are explained in more detail in PMR and ICAP, 2016.

Table 23. Benefits and Drawbacks of Permitting Offsets in a Carbon Tax

BENEFITS		DRAWBACKS	
Cost-containment	The use of offsets can reduce costs for covered entities by permitting them to reduce emissions in sectors where mitigation costs are lower. The extent to which costs are reduced will depend on factors such as the cost of emission reductions in other sectors and the supply and demand on the offsets market. This reduced cost can make the carbon tax more palatable and provide a means to counteract identified leakage risks.	**Reduced revenues**	As discussed above, permitting offsets will reduce the amount of revenue generated by the carbon tax, and so reduce the scope for other revenue use options.
Emission reductions in uncovered sectors	Applying a carbon tax may not be feasible for certain sectors and activities due to high administrative or MRV costs in the sector as a whole. Offsets can provide a way to target at least part of the emission reductions in these sectors.	**Reduced incentive for emission reduc-tions in covered sectors**	To the extent offsets are permitted and available at a lower price than the tax rate, covered entities will have less incentive to reduce their own emissions, undermining the effectiveness of the carbon tax in reducing emissions in covered sectors. This risk is lower when technical mitigation options in the sector are limited anyway.
Private sector capacity develop-ment	A dynamic and well-functioning offsets market can work to engage the private sector in identifying emission reduction opportunities and foster the development of private sector capacities in project development, MRV, and trading. This is particularly useful where the jurisdiction foresees a future ETS, but is also useful in the absence of emissions trading.	**Environ-mental integrity risks**	Since offsets are based on the estimation of emission reductions relative to a counterfactual scenario, there are inherent environmental integrity risks that do not arise under carbon taxes themselves. Existing offset standards have experienced significant challenges in ensuring the integrity of baselines and additionality tests, as well as the monitoring and verification process, leading to questions over whether credits actually represent emission reductions. While some of these concerns have been addressed and experience has allowed for improvements to be made, some challenges are inherent to offset systems and may always present a risk.
Govern-ment capacity develop-ment	The development and operation of an offsets program and market regulation bodies facilitates the development of government capacities in emissions measurement and auditing, and in trading systems. As with the private sector, this is particularly useful where emissions trading is foreseen, but can also be useful otherwise.	**Risk of market flooding**	Offsets are a market-based tool, and their introduction can reduce the price certainty that is one of the carbon tax's main strengths. Previous experience under the Kyoto Protocol's mechanisms saw an oversupply of offsets leading to markets being flooded and prices dropping to near zero. Governments can potentially mitigate this risk by limiting offset use or setting the value of offsets for compliance purposes based on their market price, rather than on the amount of emission reductions they represent (box 30).
Techno-logy neutral	While some limitations may be placed on eligible project types, within these limitations, offsets are technology-neutral, allowing the market to identify the most cost-effective emission reductions. This has the advantage of incentivizing innovation and not artificially creating "winners," though in some cases it can lead to offsets being generated for many "low-hanging fruits" that could have been more cheaply accessed by other policies.	**Administ-rative costs**	Offset programs require a good deal of administration, which can involve substantial costs for the government, though these costs can in many cases be recovered through participation or issuance fees.
		Transac-tion costs	Offsets typically involve high transaction costs for liable entities, which may reduce their economic efficiency relative to the direct emission reduction incentive provided by the tax. A related issue is where reductions are achieved relatively cheaply, but a high price is paid for offsets, resulting in large profits for offset providers. This means the forgone revenue from the carbon tax has funded these profits rather than only financing the emission reductions.

Table 24. Carbon Tax Revenue Use, by Jurisdiction

JURISDICTION	USE OF CARBON TAX REVENUE
Australia	Assistance for low-income households, including income tax reform Jobs and competitiveness, including emissions-intensive trade-exposed (EITE) companies Compensation for coal-fired electricity Use of offsets Clean Energy Finance Corporation (a green bank)
British Columbia	Income tax reductions and credits Property tax reductions and credits
Chile	General budget, intended for spending on education and health
Denmark	Reduced taxes on labor Energy efficiency and environmental programs Reduced industry contributions to government programs
Finland	Income tax reductions Decreased employer social security payments General budget
France	Reduced corporate income taxes Reduced labor taxes Energy assistance for low-income households
Iceland	General budget
India	Clean energy and environment
Ireland	General budget / deficit reduction / debt payments
Japan	Clean energy technology Energy efficiency
Mexico	General budget
Norway	General budget Reduced labor taxes Decreased capital income taxes Pension plan for low-income individuals
Portugal	Income tax reductions for low-income households General budget
South Africa	Electricity levy reduction Energy efficiency Solar tax credit Renewable energy Energy services for low-income individuals Public transport Rail freight transport
Sweden	General budget Reduced labor and corporate taxes
Switzerland	Reduced health insurance premiums Decreased social security contributions Building energy efficiency Technology development
United Kingdom	General budget

acceptance of the carbon tax from key constituencies, and where it is important to gain support from different groups, multiple strategies may be needed.

Jurisdictions have of course also adapted their practice to their individual contexts. Relevant circumstances that might influence jurisdictions' choices regarding spending include:

- **Legal restrictions.** Each jurisdiction will be making its decision within a specific legal system that may constrain options. For example, some jurisdictions have restrictions on how tax revenues can be used, such as the United Kingdom or Chile, where earmarking is prohibited, or California, where it is required.
- **Existing taxes.** To assess the opportunities for efficiency-enhancing tax reform, jurisdictions will need to assess their tax structures and evaluate their marginal costs of public funds.
- **Administrative capacity.** Some options will require additional administrative capacities and resources. Developing and administering an offset program, in particular, requires substantial administrative capacity. Where this is lacking, there is a real risk of the program not functioning properly and low-quality offsets entering the market.
- **Public awareness opportunities.** Some of the options, particularly reducing distortionary taxes, are not highly transparent to the public. Jurisdictions should assess their capacity to communicate the advantages of such approaches to the public, particularly where public support is a major concern in the adoption of the carbon tax.

Key Considerations

- Carbon taxes can raise significant revenue and how this is used can have important effects on the overall economy, the efficiency of the tax system, public welfare, and potentially the acceptability of the tax by key stakeholders. For these reasons, it is important for policy makers to carefully consider how the revenue will be used.
- Recycling revenue to allow for tax cuts elsewhere in the economy is widely considered the most economically efficient means of using carbon tax revenue, and has been broadly used by governments seeking to improve the efficiency of the tax system.
- Jurisdictions seeking to increase the mitigation impact of the carbon tax can direct revenue to low-carbon programs and incentives. Jurisdictions concerned about the distributional impacts of the tax may also direct these incentives toward low-income groups, for example, through subsidies for home insulation.
- Tax revenue can be used to help increase support for the tax among the general public and industry stakeholders, through tax cuts, rebates, or support programs. For this to be effective, it is important to clearly communicate to the public how the revenue is being used.
- Permitting offsets can promote cost-containment and encourage emission reductions in uncovered sectors, but will lead to reduced revenue. While this can be conceived as directing tax revenue to emission reductions beyond the scope of the tax, it will also result in reduced mitigation within taxed sectors.

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9 ENSURING OVERSIGHT AND COMPLIANCE

At a Glance

Effective tax administration requires effective institutions and processes to implement the tax; ensure accurate measuring, reporting, and verification (MRV) of emissions; and enforce compliance with tax obligations. What are the right institutional arrangements will depend on the scope of the tax, how it is designed, and the existing legal and administrative context of each jurisdiction.

The development of institutional arrangements for carbon tax implementation involves five main steps:

1. **Map required roles and functions.** These functions can broadly be grouped under three headings: determining tax liability, overseeing tax administration, and enforcing the tax, though specific needs will depend on the scope of the tax and how it is designed.
2. **Map existing competences and assign functions.** This allows jurisdictions to determine which existing institutions can assume those functions and where new structures are needed.
3. **Establish procedures.** Develop procedures for issues such as MRV of emissions, tax assessment and payment, audits of tax reports, and determining eligibility for rebates and exemptions. These may follow existing rules or require new or adapted rules.
4. **Strengthen capacities.** New or strengthened capacities will often be needed, both in the government and in liable entities, and in other parties such as external verifiers.
5. **Ensure coordination.** Carbon taxes often interact with a range of policies, thus coordination between government departments is important throughout the processes. This will typically be a greater concern for broader carbon taxes with a range of novel design features.

Some carbon tax designs will also require a robust framework for MRV. This can also be conceived in five main steps, as follows:

1. **Program coverage.** The sectoral scope of the tax and the point of regulation are major factors in determining the type of MRV that will be needed.
2. **Emission quantification.** Carbon taxes may apply direct monitoring or calculation-based approaches. The sectoral scope and point of regulation strongly influence this decision.
3. **Reporting procedures.** In either case, the government needs to establish reporting templates and timelines, whether for reporting actual emissions or proxies such as fuel sales.
4. **Reporting platform.** Regulating authorities need to develop a data management system that collects and stores corporate-level emissions data or proxies such as fuel sales from liable entities.
5. **Quality control and assurance.** This includes auditing tax declarations and, where liable entities are responsible for measuring and reporting emissions, verifying the accuracy of reports.

Finally, for a carbon tax to be effective, liable entities must comply with their tax obligations. To promote compliance, it is important to first understand the main avenues of noncompliance prevalent in the jurisdiction. Once this is understood, there are two key strategies to address noncompliance:

- **Include clear and meaningful penalties for noncompliance.** Some liable entities might intentionally avoid payment. To discourage this behavior generally, jurisdictions can specify clear penalties that are sufficiently high to make compliance more attractive than noncompliance.
- **Design the carbon tax itself to minimize noncompliance.** By understanding the strategies and avenues by which liable entities avoid compliance, it may be possible to design the tax in a way that limits opportunities for illegal behavior, for example, by ensuring simplicity, transparency, and a design that matches government capacities.

9.1 INTRODUCTION

Implementing a carbon tax requires adequate governance and oversight for administering the carbon tax; ensuring accurate MRV of emissions or proxies such as fuel use; and providing for oversight and compliance with tax obligations. One of the advantages of carbon taxation as a policy option is that jurisdictions will already have a revenue collection framework and a revenue body in place, and to the extent possible, jurisdictions will seek to align the administration of a carbon tax with existing frameworks and institutions. A carbon tax will in some cases however require new institutional capacities and new institutional relationships in and between public bodies.

Developing the right institutional arrangements for administering a carbon tax will be a function of the scope of the tax, how it is designed, and the existing legal and administrative context of each jurisdiction. This chapter provides guidance to help jurisdictions determine their institutional needs and develop context-appropriate arrangements based on these needs (section 9.2). Beyond providing overall guidance on establishing institutional arrangements, it also zones in on two important issues in carbon tax administration: designing an MRV system (section 9.3) and ensuring compliance with carbon tax obligations (section 9.4).

9.2 DEFINING INSTITUTIONAL ARRANGEMENTS

Administering a carbon tax requires that there be institutions with the functions and capacities necessary to implement it. Designing effective institutional arrangements requires first an understanding of the actions needed to oversee and implement the tax, and then designing a set of institutional arrangements to meet these needs. This section discusses the basic steps involved in this process, as depicted in figure 20.

9.2.1 Map required roles and functions

The first step in designing institutional arrangements for the carbon tax is to map the various functions that need to be carried out in administering the tax. These functions can broadly be grouped under three headings: determining tax liability, overseeing tax administration, and enforcing the tax. Figure 21 identifies the main tasks normally involved in each of these areas. It also shows the links between tax implementation and the policy formulation and rulemaking stage. These latter functions tend to follow the general policy-making procedures of each jurisdiction, and are not considered in detail here, although chapter 3 sets out some of the specific considerations carbon tax adoption raises.

As can be seen in figure 21, some functions of carbon tax implementation are relatively standard, while others are more strongly affected by its design. Two design features have particular relevance in this context: the scope of the carbon tax and the existence of flexibilities and complementary programs.

9.2.1.1 Relevance of scope of carbon tax

The sectoral scope and point of regulation of a carbon tax affect, among other things, the kinds of entities the tax targets and the way tax liabilities are measured. These elements have important implications for institutional arrangements.

Figure 20. Steps for Establishing Institutional Arrangements for a Carbon Tax

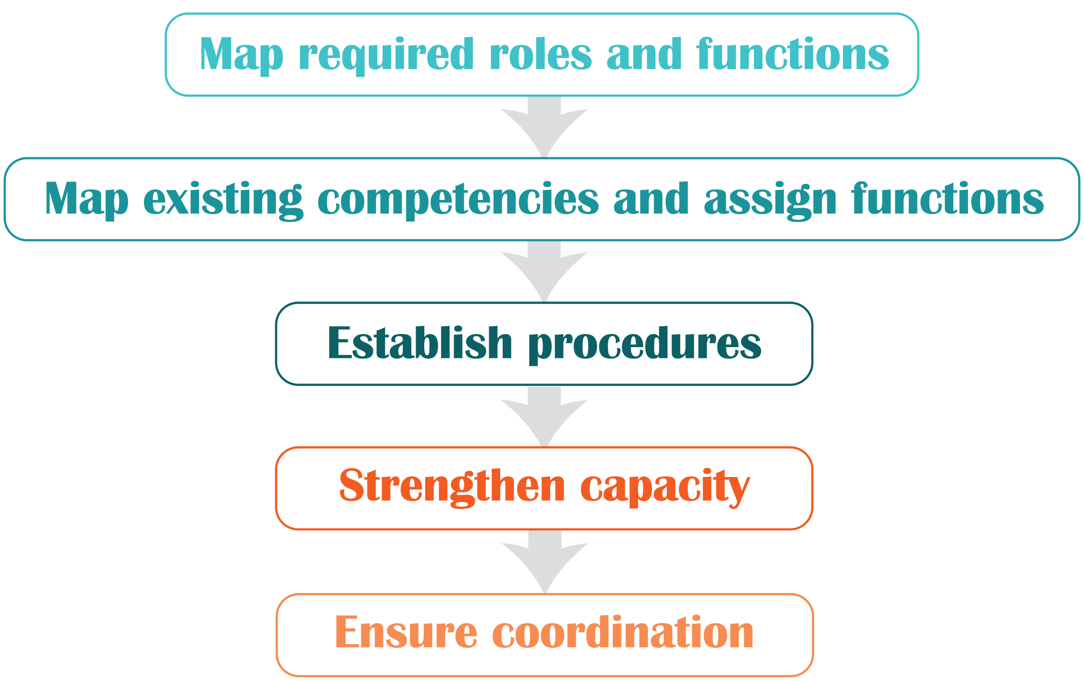

Figure 21. Institutional Roles and Tasks for Carbon Tax Implementation

1 Legislation

Legislative body adopts legislation and delegates rulemaking powers to ministries or agencies to create secondary legislation/policy where primary legislation is silent

2 Policy coordination

Tasks	Potential Institutions
Create interinstitutional body(s)	Lead ministry or agency
Coordinate rulemaking and implementation strategies across ministries or agencies	Interministerial group
Review effectiveness and propose legislative amendments to lawmakers	Interministerial group
Inform policy making with input from stakeholders	Consultative forum for civil society experts and private sector

3 Rulemaking

Finance ministry | Env. ministry | Energy ministry

Tasks	Potential Institutions
Determine methodologies for calculating carbon emissions (if not in legislation)	Environment and/or energy ministry or agency
Determine enforcement regime (if not in legislation)	Revenue authority
Oversee comment submission process on rules	The relevant government ministry or agency

4 Implementation

Tax liability

Tasks	Potential Institutions
Oversee reporting for upstream suppliers/refiners of fossil fuels	Entity responsible for excise tax (e.g., revenue authority)
Oversee emissions reporting and verification for midstream electricity utilities	Environment ministry or agency / Energy ministry or regulator
Oversee emissions reporting and verification for downstream electricity utilities	Environment ministry or agency
Determine tax owed based on above data	Liable entities / Revenue authority
Determine tax liability for importers	Customs authority
Auditing of emissions reports	Environment agency / Independent verifiers
Administration of offset program	Environment or Energy ministry or agency

Tax administration

Tasks	Potential Institutions
Process and review tax returns	Revenue authority
Assist liability entities to meet tax responsibility and identify potential non-compliance	Revenue authority

Tax enforcement

Tasks	Potential Institutions
Investigate noncompliance	Revenue authority and law enforcement agencies (if not within revenue service)
Prosecute noncompliance	Revenue authority and judicial system

Table 25. Institutional Arrangements for Implementing Chile's Carbon Tax

TASK	INSTITUTION
Determining social price of carbon (which informed tax rate)	Ministry of Social Development
Identifying entities liable to pay tax and publishing list of liable entities	Ministry of Environment
Establishing administrative procedures for tax application	Ministry of Environment
Establishing measuring, reporting, and verification (MRV) requirements	Superintendence of the Environment
Ensuring compliance with MRV requirements	Superintendence of the Environment
Consolidating the emissions reporting of covered entities	Superintendence of the Environment
Managing interactions between carbon tax and electricity market / electricity pricing regulation	National Energy Commission and Independent Coordinator of the National Electricity System (CISEN)
Receiving taxes	General Treasury
Collecting taxes and enforcing tax obligations in case of noncompliance	Internal Tax Service

As discussed in chapter 5, most carbon taxes implemented to date have applied the tax to specific fuels, primarily oil, gas and coal, and in some cases peat. These taxes typically "piggyback" on existing excise and customs taxes on mineral oils or solid fuels, and so are administered according to existing processes. This is the case, for example, in British Columbia, Portugal, and Japan. In most cases, the creation of additional functions is limited, since revenue authorities already have a system in place for monitoring and collecting tax (based on fuel volume), and so can easily calculate carbon tax obligations (based on the application of a defined emissions factor).

One additional function that may be required in these cases is to distinguish between fuels with similar external properties but different carbon contents. For instance, in Mexico, customs authorities received additional training to help them distinguish between oil-based fuels and biofuels.

In the case of jurisdictions that decide to target direct emissions, a range of new functions may be required in addition to those involved in basic tax administration. In particular, monitoring emissions will typically be more complex in other sectors and will usually involve establishing frameworks for MRV and assigning institutional responsibility for overseeing reporting and verification of emissions and calculating tax liabilities (section 9.3). The case of Chile (table 25), which has adopted a midstream tax on electricity generators and other large boilers and turbines, provides an illustration of the range of functions that may be required under this kind of carbon tax.

9.2.1.2 Relevance of flexibilities and complementary programs

Several jurisdictions have built flexibility into their carbon tax that allows liable entities to be partially or fully exempted from their tax obligations. For example, entities may be allowed to enter into voluntary agreements to reduce their emissions in return for partial refunds (as in the case of Denmark) or may be exempted from the carbon tax (as in Switzerland). Similarly, entities may be allowed to use offsets to pay for part of their tax obligations (as foreseen in Mexico).

Including additional features such as these will in most cases require additional institutional capacities to manage these programs. Institutional responsibilities will therefore need to be assigned for their administration, including ensuring oversight and determining the eligibility of liable entities for these flexibilities. The entity in charge will also need to ensure coordination with those overseeing the actual administration of the tax (i.e., revenue collection and enforcement).

9.2.2 Map existing competences and assign functions

The second step, once the required functions for carbon tax implementation have been determined, is therefore to map the existing institutions that have the relevant (legal) competences and institutional capacities to carry out those functions. Jurisdictions differ in the relative division of responsibilities between departments of government, and the institutional arrangements for a carbon tax will reflect these historical institutional structures. Capacities for carrying out different tasks will also vary across institutions.

One of the advantages of carbon taxes as a policy option is that jurisdictions will already have a revenue collection framework and a revenue institutional setup in place. In the case of *carbon taxes on fossil fuels*, all the main functions for implementing the tax can often be fulfilled by existing tax administration authorities. For example, in Japan and British Columbia, the Ministries of Finance administer the tax, while in Ireland and the United Kingdom, the tax is administered by the Revenue Commissioners and HM Revenue and Customs, respectively. In some jurisdictions, tax authorities will cooperate with justice authorities in the enforcement of tax obligations. For example, in Mexico, the Federal Attorney General's Office for the Protection of the Environment plays an important role in ensuring compliance with tax obligations.

In the case of carbon taxes that are applied to *direct emissions*, entities other than tax collection authorities will often be charged with overseeing emissions monitoring. Where entities already exist with similar functions, these responsibilities will often be assigned to these entities. For example, in Chile, the Superintendence of the Environment, which is the authority with responsibility for ensuring compliance with environmental laws, was tasked with developing the MRV system and overseeing emissions reporting. Other existing competences and processes that can be built on include the monitoring of sulphur dioxide, nitrous oxide, and other pollutants from fossil fuel power stations, or the monitoring of industrial output. Energy ministries may also participate by providing information on energy usage to entities overseeing emissions monitoring, as is the case in South Africa.

Where carbon taxes include *flexibilities*, jurisdictions will also seek to involve entities that already implement similar programs. In Denmark, the Danish Energy Agency—already responsible for the implementation of the energy efficiency measures (including subsidies) in all sectors, except the transport sector—was made responsible for administering agreements with liable entities under which they could earn carbon tax rebates by entering into binding energy efficiency agreements with the government. In this way, Denmark was able to take advantage of existing capacities as well as ensure alignment with other programs.

By contrast, where there is no institution with the right legal competences and the required institutional capacities to undertake the tasks required, jurisdictions may *establish new structures*. This was the case, for instance, in Australia's Carbon Pricing Mechanism, which had a broad scope and required significant new competences to be developed. For that reason, the government established a new entity, the Clean Energy Regulator, to oversee administration, which also assumed a number of existing functions such as overseeing the Renewable Energy Trading Scheme and the Carbon Farming Initiative.

A related issue to consider together with mapping existing institutions is the jurisdiction's *broader policy framework*. A carbon tax may only be the first step in a government's long-term plan to control emissions, and the division of responsibility between institutions for administering a carbon tax should ideally feed into the institutional arrangements required to implement policies in the long term. For example, a government may wish to introduce a carbon tax as a carbon-pricing stepping stone to the introduction of a more complex ETS in the future. For example, Chile's carbon tax and MRV system were designed in a way that would facilitate the possible implementation of an ETS in the future, among others, by seeking to align methodologies with existing ETSs in other jurisdictions. Similarly, Australia's decision to create a new regulatory entity was influenced by its intention to transition the carbon tax to an ETS.

9.2.3 Establish procedures

Once institutional roles have been determined and assigned, it is important to define the procedures to be followed in carrying them out. Clearly defining rules and procedures through legal instruments and policy guidance documents helps to provide clarity to regulators and regulated entities alike, and facilitates a smooth administration of the carbon tax. Procedures may need to be adopted for a range of actions, including:

- MRV of emissions (section 9.3)
- Tax assessment and payment
- Claiming rebates
- Audit and inspection
- Investigation of fraud and prosecution
- Surrendering offsets or claiming exemptions based on flexible mechanisms
- Undertaking revisions to carbon tax rules.

Jurisdictions will invariably already have a range of existing procedures that apply to tax administration. Whether new procedures are required or existing procedures need to be adapted will depend to a large extent on how easily the design of the carbon tax fits within the legal framework of existing taxes and what additional design elements it contains that may require special consideration. This will differ significantly depending on the specific characteristics of each carbon tax and the existing tax administration framework. Nonetheless, the experience to date highlights three broad approaches:

- **Full integration.** The carbon tax can be fully integrated within an existing tax, usually an excise tax, so that the amount of the carbon tax is simply fused with the amount of the excise tax to form, for administrative purposes, a single combined tax rate. This is the approach adopted for the portion of the Irish carbon tax that covers mineral oils, where mineral oil traders file only one return for their mineral oil sales.

- **New instance of existing category.** The carbon tax can be defined as a specific tax or subcategory of taxes within an existing tax category. This allows for the application of the overall rules of that tax category, while differentiating or adding supplementary rules as necessary. This is the approach taken in Mexico's carbon tax, which is deemed part of the Special Tax on Production and Services. Similarly, in South Africa, the proposed tax would be administered as if it were an environmental levy as defined under existing legislation, but would also be subject to a range of rules defined through the (currently proposed) Carbon Tax Act and its subsidiary legislation.
- **Stand-alone tax category.** Where the tax does not fit within existing categories or certain design features require tailored procedures, jurisdictions may define a new tax category and a specific set of procedures. For example, in British Columbia, constitutional considerations necessitated that the tax be levied on purchasers of fuel; however, as it would not be practical for the government to collect taxes from each individual purchaser, it developed a new system whereby the suppliers are required to pay securities and then collect the tax from the purchasers.

9.2.4 Strengthen capacity

It can be expected that any new carbon tax will require the development of new capacities or the strengthening of existing ones. This need will be greater where the carbon tax has design features that require new competences, and in jurisdictions with less well-developed tax administration capacities, though in all cases some additional capacities are likely to be needed. The following sets out the most important needs that can be expected to arise and the principal methods that can be used to build capacities.

9.2.4.1 Identification of capacity-building needs

"Capacity" can be defined as the specialized understanding, skills, institutions, processes, and resources required to design and implement a carbon tax. Capacity-building needs can be assessed by conducting capacity needs assessments that compare the roles and functions identified above (section 9.2.1) with the capacities of the institutions that have been designated to implement that carbon tax. It is worth noting that where governments adopt revenue-neutral carbon taxes, the reductions in other taxes may free up capacity that can be used to administer the carbon tax. While it is important that the broader government, business community, and general public have sufficient information to understand the rationale and overall functioning of the carbon tax, several stakeholders will require more specialized capacity. Important among these are:

- **Government departments** involved in carbon tax design and implementation will need the capacity to fulfil new functions, such as:
  - Identifying and evaluating carbon tax design options
  - Drafting carbon tax legislation, regulations, and technical guidelines
  - Administering core carbon tax functions: measurement and verification of emissions, tax collection and administration, enforcement, assessment, and review
  - Administration of flexibility mechanisms such as offsets or energy efficiency agreements
  - Managing the carbon tax's fiscal implications for and impacts on other government policies, measures, and administrative systems.
- **Regulated entities** will need the capacity to meet their carbon tax (payment) obligations. In cases where the carbon tax uses simply proxies such as fuel use or "piggybacks" on existing systems, regulated entities will often need new capacities to monitor and report on emissions.[58] They will also need to develop new skills and processes for factoring carbon prices into business decisions, developing overall mitigation and investment strategies, and hedging against new risks and uncertainties.[59] Where the carbon tax seeks to change the behavior of consumers, they will similarly need information on available options to reduce their emissions.
- **Other entities** will, where relevant, need the capacity to design facilitative services such as supporting regulated entities to reduce their emissions or engage in flexible mechanisms. Auditors and third-party verifiers will also need capacities to perform these tasks for the carbon tax.

9.2.4.2 Methods and tools for capacity building

Following an assessment of stakeholders' current capacity, the gaps that need to be filled can be identified. A program for capacity building can be designed based on the gap analysis. Key elements of this program could be:

- **Providing basic educational materials** with plain-language information about carbon design, impacts, and obligations
- **Developing guidelines** and technical documentation through a process of participant input and review, to ensure they are comprehensible and practical

[58] For detailed guidance on the capacity needs for monitoring, reporting, and verification, see Singh & Bacher, 2015.
[59] For case studies on companies' practical experience with preparing for emissions trading, see PMR, 2015.

- **Holding workshops** that create an opportunity for information sharing
- **Providing training** to staff who will be involved in carbon tax-related activities
- **Engaging researchers** to help develop a carbon tax tailored to the local context, based on experiences gained elsewhere
- **Encouraging learning from other systems** by engaging those with prior experience in carbon tax design. Study tours and inviting experts from other jurisdictions to present can be helpful in showing stakeholders how other carbon taxes are operating. The PMR and other organizations, as well as donor countries assist with capacity building through information resources, technical training, professional accreditation programs, and country-to-country exchanges.

9.2.4.3 Learning by doing

Where a carbon tax requires relatively more complex systems to monitor the emissions of covered entities, there may be room for learning by doing through the development of a GHG reporting system before adopting a carbon tax. In Australia, the prior existence of a system of MRV of emissions from large emitters greatly facilitated the smooth rollout of the carbon tax, and was expected to allow a relatively quick transition to an ETS.

9.2.5 Ensure coordination

Carbon taxes typically bring together multiple sectoral policies (e.g., energy, environment, economic/fiscal), and so coordination of both development and *implementation strategies* between government departments responsible for various aspects of tax implementation is important throughout the processes. At the policy development level, multisectoral and interministerial committees—which in many countries already exist for environment or climate policy development—may prove useful for coordinating design questions that touch on multiple policy areas. Beyond coordinating design-related matters, an interministerial body may also play a role in carbon tax implementation, as well as in reviewing its effectiveness and proposing necessary legislative adjustments.

At the administrative level, the extent of coordination will naturally depend on the number of entities involved in implementing the tax, which largely depends on its design features. In relatively straightforward carbon taxes focused only on fuel use and without direct connections to other programs, tax administration authorities will often take on the lion's share of administration. In these cases, informal and ad hoc coordination with other agencies (such as environmental authorities) may be sufficient. This is the case, for example, in Ireland. By contrast, taxes that include other sectors will often involve several authorities—including revenue authorities, environment ministries, and energy regulators—and so will need more comprehensive coordination mechanisms. This is the case of South Africa (box 29). For taxes that apply to fuel use but are linked to flexible mechanisms or other complementary programs, coordination will typically be needed between the revenue authorities and the authority implementing the complementary program, as is the case in Switzerland and Denmark.

Some principles to consider in designing coordination mechanisms include:

- **Ensure appropriate leadership.** Clear executive and ministerial leadership and commitment helps secure departmental engagement and support.

Box 29. Case Study: Coordination in the South African Carbon Tax

The South African carbon tax is set to be one of the broadest carbon taxes adopted to date and will include a range of sophisticated mechanisms to address leakage and compliance costs, including offsets and linking tax obligations to sectoral benchmarks, and participation in other emission reduction initiatives. These factors mean that multiple government entities need to be engaged in ensuring the tax is effectively administered.

Overall responsibility for administration of the tax, including receiving and reviewing reports on emissions from liable entities, will be the responsibility of the South Africa Revenue Service (SARS). The Department of the Environment is responsible for operating the South African National Atmospheric Emissions Inventory System (NAEIS), and will make data reported to this system by liable entities available to SARS to facilitate verification of reported emissions data. Both the Department of Energy and the Department of Transport will feed data into NAEIS to ensure accuracy of emissions reporting.

The Department of Energy will administer South Africa's offset program and the development of an offsets registry. When international credits are surrendered, the Department of Energy will transfer those credits to the SARS account and issue a certificate to the surrendering entity that can be used within 15 years against tax liabilities. In this way, SARS can easily verify the validity of the certificate presented by a liable entity.

Figure 22. Key Design Elements of a GHG Measuring, Reporting, and Verification (MRV) System

Source: Singh & Bacher 2015.

Note: GHG = greenhouse gas.

- **Designate decision makers.** Assigning a specific department, team, or manager to lead carbon tax development and be accountable for delivery, including to other government departments, will help define clear lines of authority and avoid uncertainty.
- **Establish special working groups.** These can facilitate interdepartmental collaboration at different levels, where challenging issues can be raised and discussed.
- **Develop communication channels.** Coordination can also be supported by establishing regular channels to communicate progress, and share information and document decisions.

9.3 MEASURING, REPORTING, AND VERIFICATION (MRV)

Carbon taxes need to be accompanied by MRV systems that provide the basis for the accurate calculation of tax liabilities, though the extent of MRV required varies significantly depending on the specific tax design (see below).

To a large degree, the considerations in designing MRV systems for carbon taxes are the same as those for developing MRV frameworks generally, a subject that has been comprehensively covered in a recent PMR guidance document.[60] At the same time, a number of design choices in designing MRV systems are influenced by the design of the carbon tax itself. This section focuses on the implications of different carbon tax design choices for each of the key design elements of an MRV system, as depicted in figure 22.

9.3.1 Program coverage

The coverage of an MRV system for a carbon tax will naturally be matched to the coverage of the carbon tax itself (chapter 5). In some cases, it may be extended to cover sectors not covered under the carbon tax, for example, to accommodate future expansion of the carbon tax or effective information management. To reduce the administrative burden on both the tax administrator and

[60] Singh and Bacher, 2015.

the reporting entities, simplified rules and procedures can be devised for participants that are not initially covered by the tax but could be covered in the future.

Carbon taxes that are applied only to fuels are usually applied upstream or midstream at the point of distribution, and emissions are measured based on the application of an agreed emissions factor (based on the carbon content of the fuel) to the amount of fuel sold. In most cases, this is done by revenue authorities, who will typically already have systems in place for measuring the amount of fuel sold for excise tax purposes. In these cases, there is no need for the establishment of an independent MRV framework, although it will be necessary to identify accurate emissions factors for different fuels used in the economy.

Additionally, where rebates are tied to fuel used for certain purposes, jurisdictions will need systems to verify the information provided on fuel use, while rebates or exemptions linked to agreements to reduce emissions will require MRV systems for those emissions.

In the case of carbon taxes applied to other sectors—such as electricity generation, industrial processes, or waste disposal—and of downstream taxes on fuel consumption, relevant MRV systems will often not exist. Moreover, the wide range of factors that influence the amount of emissions produced accounts for larger than normal complexity, making it challenging to determine accurate, complete, and consistent emissions data. One example is the accounting for emissions generated in the chemical processing industry, where it is often difficult to relate emissions to individual input materials or attribute them to a specific part of the production process. Carbon taxes in these sectors will typically require a comprehensive MRV framework be put in place. However, as noted above, such a framework can be built on existing systems used, for instance, for reporting electricity production and consumption.

Limited experience has been gained with the application of carbon taxes in sectors other than fuel use, as only two jurisdictions (Australia and Chile) have done so. Lessons can, however, be drawn from MRV frameworks put in place for other programs or purposes, such as ETSs. For example, the European Union Emissions Trading System (EU ETS) covers power stations and other combustion installations with installed capacities exceeding 20 MW. Individual installations are required to monitor their GHG emissions from all types of combustion processes, including the fuels used as process inputs. Data from the sector have been monitored, reported, and verified annually since the first phase of the EU ETS was launched in 2005, providing valuable experience for conducting MRV in the power sector.

Where carbon taxes only cover direct emissions—that is, emissions from sources owned or directly controlled by the reporting entity—the MRV system will focus on measuring emissions at the source. In some cases, jurisdictions may choose to also include certain emissions resulting from the entity's activities that are not owned or directly controlled by the entity in question ("*indirect* emissions"), for instance, emissions from electricity consumption by industry (section 5.2.2). In these cases, jurisdictions will need to ensure reporting of electricity consumption by regulated entities and establish emissions factors for calculating these emissions.

Depending on data availability, the calculation of electricity emissions may be based on national or subnational emission factors or on more accurate, utility-specific emissions factors that better reflect the GHG emissions associated with the electricity an entity has purchased.[61] In the case of downstream taxes that include Scope 2 emissions[62] from electricity use, emissions factors that more accurately reflect actual GHG emissions will provide greater incentives to electricity users to purchase cleaner forms of electricity.

The scope of an MRV system will also be linked to the amount of uncertainty that a carbon tax program will allow for. This relates to the concept of materiality, which posits that more attention should be paid to larger numbers than to smaller ones, and that consequently larger polluters should face more stringent monitoring requirements than smaller entities. The EU ETS, for instance, does not cover small power producers. Where thresholds are lower and large numbers of smaller entities are included, jurisdictions may opt to apply relatively simple MRV requirements to accommodate the lower capacities of smaller entities. Where there is a mix of larger and smaller entities, the jurisdiction may decide to adopt a multitier system that applies more stringent requirements to the larger entities, as the latter are not only more challenging but also more costly to implement.

9.3.2 Emissions quantification

Once policy makers have determined the coverage of an MRV system, the next step is to develop guidance on how GHG emissions are to be monitored and quantified. Basically two main approaches can be taken to quantify emissions, which differ in their practical implementation, degree of accuracy, and realization cost:[63]

- **Direct measurement approaches.** These approaches involve directly measuring the gas particulates being emitted from a covered emissions source. Emissions are monitored at the source, by means of installed equipment that records the GHGs vented into the atmosphere.
- **Calculation-based approaches.** These represent indirect ways of quantifying emissions by relating a given GHG content to a quantity of a specific input or activity,

[61] WBCSD and WRI, 2004.

[62] *Scope 2* emissions are indirect GHG emissions from consumption of purchased electricity, heat, or steam.

[63] See further Singh and Bacher, 2015 (section 4.2).

for instance, by applying a fuel emissions factor to the quantity of fuel used in electricity generation.

As indicated above, for upstream taxes on fuel, emissions are almost invariably measured through calculation-based approaches, specifically by applying an emissions factor to the quantity of fuel sold or purchased. This approach is used because the entity making the tax payment to the government is not the direct emitter. It is applied, among others, in Mexico, Sweden, and Japan. Similarly, where downstream electricity users are taxed, calculation-based approaches will have to be applied, as is the case in the Japanese ETS, since the point at which emissions occur is different from the point at which the tax is collected.

In the case of taxes applied to entities in whose facilities emissions actually take place—for example, electricity generators, industrial facilities (in the case of emissions from industrial processes or on-site energy combustion), or landfill operators—either direct measurement or calculation-based approaches can be applied. The direct measurement approach is particularly useful to measure GHG emissions if various fuels and other inputs are used in a given process, for example, in cement kilns. In practice, however, calculation-based approaches are still more commonly used, as they are usually less costly and less resource-intensive. This was the case, for example, in Australia's former Carbon Pricing Mechanism. Similarly, the draft South African Carbon Tax Bill refers to a calculation-based approach to both energy and industrial process emissions. Chile is expected to require direct monitoring at installations that already have "continuous emissions monitoring" systems in place, in particular electricity generators, and calculation-based monitoring approaches at other installations.

Regardless of the measurement approach used, monitoring guidelines must be available for each sector covered by the carbon tax. These guidelines can draw on a wide range of methodologies, emissions factors, calculation models, and default factors, although in some cases they will need to be tailored to the specific context of the jurisdiction and/or specific design features of the carbon tax. The degree of accuracy that is imposed through these guidelines will depend on the technical feasibility of quantifying emissions (including the availability of national or subnational emissions factors), the associated costs, and the maturity of the carbon tax program or preexisting monitoring programs.

9.3.3 GHG reporting procedures

GHG reporting procedures are put in place with the objective of regulating the scope and frequency of reporting by covered entities. Well-defined reporting templates, GHG emission models, and verification procedures are key to ensuring timely compliance and enforcement.

As discussed above, where carbon taxes are applied to fuel sales, taxing authorities typically calculated emissions by applying standard emission factors to quantities sold or purchased. In these cases, covered entities will usually not be required to report emissions, but simply report on fuel quantities. Supplementary information may also be required, such as on the details of major sales or on the largest purchasers.

In the case of taxes applied to direct emissions sources, GHG data reporting typically consists of information relating to the reporting entity's covered assets, total emissions generated over the monitored period, differentiation between various tiers of GHG emissions, and the underlying emissions calculation models. For some industries, such as the power supply sector, the monitoring procedures and data analysis steps will be broadly in line with what entities are already tracking under a business as usual (BAU) scenario for their daily business operations (e.g., under ISO data management standards). For others, such as chemical processing or cement production, the associated monitoring costs may be higher, depending on the MRV scope, as sometimes the monitoring parameters under approved MRV methodologies are not captured in plants' usual operation monitoring systems.

As indicated in the previous section, the level of uncertainty permitted will also define the amount of resources that will have to be dedicated to GHG monitoring and reporting procedures. For example, minimum tier levels defining data quality levels of specific parameters will need to be defined for the determination of emissions reporting. The EU ETS Monitoring and Reporting Regulation, for example, clearly specifies what minimum tier levels are required per monitored activity, and only allows for deviation in circumstances where entities can demonstrate that the highest tier is technically not feasible or implies incurring unreasonably high costs.

Other relevant considerations are the reporting period and timelines for submitting documentation to the overseeing authority. Reporting periods will typically be aligned with the accounting period for payment of the tax. Where the carbon tax is, for administrative purposes, defined as part of an existing tax (section 9.2.3), the accounting periods for that tax will also apply to the carbon tax. This is the case, for example, in Ireland, where tax returns covering the liquid fuel carbon tax are filed monthly as part of overall tax returns on mineral oils.

By contrast, where independent procedures for the carbon tax are adopted, the government will have to make an independent decision on reporting periods. Here it is important to take into account the burden on the reporting entity. Where the type and amount of information to be reported is minimal, more frequent reporting is feasible. This is the case under the Clean Environment Cess in India, where producers are only required to report on the quantity of fuel mined or imported, and reporting must be done monthly. In South Africa, on the other hand, where covered entities are expected to be responsible for calculating emissions based on defined methodologies, it is proposed that reports be submitted biannually.

Besides regulatory requirements for the frequency of monitoring and reporting, liable entities may also decide to monitor more regularly or even monitor on a continuous basis to gain a better understanding of evolving outstanding tax liabilities. Finally, MRV schemes that accept lower certainty levels (i.e., permit the use of lower tiers) may also allow for less frequent monitoring intervals to avoid the incurrence of unreasonable costs. In the case of jurisdictions with relatively onerous reporting requirements of this kind, governments will often provide some time between the end of the reporting period and the final submission to the respective authority, usually 2–4 months, depending on the complexity of reporting.

9.3.4 Reporting platform and data management system

To effectively administer a carbon tax, regulating authorities need to develop and implement a data management system that collects and stores corporate-level GHG inventory data from companies and organizations.[64] This is important for ensuring accurate determination of tax liabilities, but also for keeping overall track of the implementation of the carbon tax—for instance, changes in emissions of covered entities over time—which is important for feeding data into policy evaluations and reviews. This data management system can also serve other purposes not related to the carbon tax, such as complementing national GHG inventories and reports.

The intricacy of the applied system will depend on the level of detail that is needed to meet predefined MRV requirements, and can range from relatively straightforward spreadsheets to more sophisticated online systems. To decide on the scope and technical specifications of the reporting platform, policy makers should consider, among others:

- Type of data that needs to be reported
- Frequency of reporting
- Number of entities covered under the scheme
- Potential to scale up the coverage of the scheme in the future
- Capacity and comfort of the reporting entities (relevant for online platforms)
- Setup and operating costs
- Availability of existing platforms that can be adapted for this purpose
- Available technical (IT) capacity to design and maintain the platform
- Possibility to engage third-party verifiers.

The definition of the tax base and point of taxation will guide the design of the appropriate data management platform. For example, a tax on the supply of fuel will typically be based on a standard emissions factor per fuel supplied, which is relatively easy to monitor and will not require layered data input functions. Applying taxation to electricity generation at the generator level, on the other hand, is more complex, and will require a more sophisticated data management system that consolidates and verifies inputs (see the case of Chile, described in box 30). Whether a carbon tax is applied downstream or upstream will also be a factor in the design of the reporting platform—due to the variable taxation base (e.g., larger amount of entities further downstream) and different emissions quantification approaches.

Regardless of the underlying software solution, a number of elements need to be in place for any reporting platform to work effectively. Given the link between GHG emissions generation and performance, sharing emissions data is a sensitive issue. Ensuring security and data confidentiality should therefore be at the forefront of any reporting platform to gain the trust of the reporting entity. Moreover, introducing differentiated levels of access to qualified users and incorporating tested security provisions are key to preserving the integrity of the data management system used.

Another important consideration is the standardization of data forms to improve consistency in reporting and minimize the incidence of errors. Including data such as approved emissions factors and narrowly defining data entry fields can serve to increase transparency and accuracy.

9.3.5 Quality control and assurance

Quality control and quality assurance—including verification of emissions measurement and reporting—form an integral part of a carbon tax MRV system. The activities related to them ensure that the outputs produced along the entire chain, starting with data collection and ending with emissions verification, are accurate and complete. It is important to distinguish between two terms:

- **Quality control.** This refers to the checks applied on the side of the reporting entity. The basis for ensuring quality and consistency is a monitoring plan that reporting entities should be incentivized to develop. A monitoring plan serves to set out in detail all procedures relating to the data collection process, including the emissions quantification approach, monitoring parameters, and measurement frequencies. Quality control is an important part of the MRV of direct emissions, but is less relevant for the simpler reporting process in the case of upstream fuel taxes.

[64] Detailed guidance on the development of such data management systems has been provided in the recent PMR technical note, Greenhouse Gas Data Management Building Systems for Corporate/ Facility-Level Reporting (PMR, 2016).

Box 30. Case Study: Data Management System for the Chilean Carbon Tax

In Chile, the Pollutant Release and Transfer Register (PRTR) is a one-window system that is being leveraged to report CO_2 emissions for the purposes of the carbon tax. The government expects to undertake a three-year development process (2015–18). The system is designed to be ETS-compatible, so as to accommodate potential future policy changes. The PRTR system registers contaminants at the source—capturing 90 percent of all sources in Chile—and enables disclosure of information to the necessary stakeholders, including communities and the public. Chile designed and conceptualized the structure, but subcontracted experts to develop and implement the information system, and to support the government in developing additional modules (on environmental expenditures, voluntary GHG reporting, etc.).

- **Quality assurance.** This consists of an additional check to verify that the reported GHG emissions data indeed reflect the best possible estimates, given available data and the applied measurement approach. Generally, this step is undertaken by authorities administering the policy measure or certified third-party auditors. Verifications typically target key monitoring parameters, and reviewing the accuracy of the underlying data collection process and quality control measures applied.

The extent of quality control and assurance needed in a given jurisdiction relates to the coverage of the carbon tax regime and the point of taxation. Where covered entities are only required to report on quantities (e.g., of fuel sold), auditing will only need to cover this information. For example, under India's Clean Environment Cess, excise officers are allowed to inspect the premises of registered coal producers and audit records to determine compliance with tax payments.

However, if entities are required to measure emissions according to defined methodologies, more complex verification that looks at the accuracy of measurement will be required. The type of emissions quantification approach is also important in this context—direct measurement approaches are usually more complex and will require more in-depth verification than calculation approaches.[65]

Policy makers can support quality control efforts by producing templates and manuals for developing monitoring plans, and assisting with the reporting by disseminating online resources (on reporting best practices) or organizing courses for participants. Preceding the carbon tax with a voluntary monitoring system, as was done in Chile (box 30), can also help covered entities improve their quality control processes.

A key consideration in defining quality assurance processes is determining whether to assign responsibility to government entities or to independent verifiers. Where governments want to assume this role internally, they need to ensure adequate in-house capacity and resources are available. On the other hand, where third-party verifiers are used, it is important to adopt measures to ensure the qualifications and impartiality of verifiers, and to provide for government oversight, for example, through random audits and complaint mechanisms.

Governments can also opt for a hybrid approach. In South Africa's National Atmospheric Emissions Inventory System (NAEIS)—intended to be used for the assessment of obligations under the forthcoming carbon tax—local "air quality control officers" have the power to request clarifications regarding information they believe may be incomplete or inaccurate. Where they are not satisfied with these clarifications, the air quality control officers can order that the information be verified by an independent verifier.

In systems that adopt offsets or other complementary programs such as energy efficiency agreements linked to tax exemptions, third-party verifiers may be able to cover both verification of covered entities' emissions reports and offsets or other programs.

9.3.6 Practical considerations

Most jurisdictions will already have a system in place for reporting and verifying quantities of fuel used, and in the case of upstream or midstream taxes on fuel, this can be used as the basis for calculating carbon tax obligations. This is, for example, the case of carbon taxes applied in EU Member States such as Sweden, Denmark, and France, where fuel production, import, and sale are monitored pursuant to the Excise Movement and Control System.

For jurisdictions that have not yet adopted related environmental legislation and lack institutional capacity to introduce, administer, and enforce broad taxation, the carbon taxes and underlying MRV system could be implemented in phases. By starting with the implementation of MRV, targeting one key sector or several large emission sources, both the capacity of the authorities administering and enforcing taxation and the entities covered by the scheme can be enhanced. Following the initial learning period, MRV obligations can be extended to other sectors.

MRV systems supporting the administration of a carbon tax can also build on or relate to existing institutional capacities that have been put in place to implement similar

[65] National Atmospheric Emission Reporting Regulations, No. R.283, 2 April 2015.

policies. Jurisdictions may already have implemented specific renewable energy or energy efficiency programs that at least partially cover the requirements set forth in the MRV system supporting carbon taxation. Jurisdictions where a cap-and-trade scheme is envisaged or is already operational will also have certain MRV procedures in place, which could also be applicable to sectors targeted by a carbon tax. For example, Australia's former Carbon Pricing Mechanism MRV was based on the preexisting National Greenhouse and Energy Reporting Scheme.

Jurisdictions can also adopt a voluntary system prior to carbon tax adoption to build the capacities of both regulators and covered entities. For example, Chile adopted a voluntary emissions reporting system known as Huella Chile, which was applied to the power sector prior to carbon tax adoption.

9.4 DESIGNING FOR COMPLIANCE

For a carbon tax to be effective, it is essential that liable entities comply with their tax obligations. To promote compliance, three mutually reinforcing strategies may be used:

- **Ensure that liable entities understand their obligations.** Not all tax noncompliance is intentional. To comply, liable entities must understand their obligations under the carbon tax. Jurisdictions can organize public information campaigns to promote awareness. By establishing public education initiatives and capacity building in the private sector, the jurisdiction enables entities to understand the processes by which their tax liabilities are determined and met.
- **Design the carbon tax itself to minimize noncompliance.** By understanding the strategies and avenues by which liable entities avoid compliance it may be possible to design the tax in a way that limits opportunities for illegal behavior.
- **Include clear and meaningful penalties for noncompliance.** Some liable entities might intentionally avoid payment. To discourage this behavior generally, jurisdictions should specify clear penalties that are sufficiently high to make compliance more attractive than noncompliance.

This section focuses on the latter two strategies for controlling intentional noncompliance—tax design and penalties.

9.4.1 Maximizing compliance through carbon tax design features

The specific design of a tax system (e.g., whether the tax is applied upstream or downstream, the breadth of coverage of the tax, and the tax rate) can affect the level of noncompliance. To understand how best to design and enforce taxes for compliance, however, it is important to first consider the avenues by which intentional noncompliance arises.

9.4.1.1 Risks of noncompliance

The channels of noncompliance follow two basic patterns. First, liable entities may act independently to evade their obligations by using different strategies, including:

- **Nonreporting or misreporting of emissions or emissions proxies.** Because so much of the monitoring in a carbon tax system is conducted through self-reporting, liable entities might seek to reduce their tax bill by misreporting key factors that are used in calculating GHG emissions, for example, the amount of fuel consumed or sold, the amount of land brought under low-carbon tilling practices, or even the technologies that are used in an industrial process (e.g., cement manufacturing).
- **Providing false information to auditors.** Liable entities may produce false or reworked records, attempting to hide or obfuscate their activities. To enforce compliance, tax authorities should conduct both random and targeted auditing of tax records. For example, in Australia, the National Greenhouse and Energy Reporting Act gives regulators the authority to enter and inspect the property of regulated entities if they expect efforts to violate the act. In addition, regulators have the authority to order an audit into regulated entities' emissions reporting. Similarly, in Chile, the Internal Tax Revenue Service can order audits of taxpayers suspected of evasion.
- **Nonpayment of tax liability.** Some liable entities might accurately report their emissions but still not pay their taxes, either because they are unable to pay or because they hope to avoid the cost of payment.
- **Smuggling of carbon-intensive goods.** Where jurisdictions have implemented carbon taxes on fossil fuels or border adjustments on carbon-intensive goods, some parties might attempt to smuggle the goods to avoid carbon taxes levied at the jurisdiction border. In a variation of smuggling, importers could mislabel goods, claiming they originated in a country that has a carbon tax. This can be a problem especially when there is a differential tax across fuels that appear similar. In Mexico, for example, the customs authorities have been provided with additional technical support so they can distinguish between different fuels, in particular between biofuels and liquid petroleum.

All of these are forms of tax evasion—illegal practices to avoid payments.

Secondly, in some jurisdictions liable entities may seek to enlist government representatives to undermine the integrity of the tax system by rendering preferential treatment in return for payment (bribes) or career advancement (jobs). Preferential treatment can include rendering favorable interpretations of the tax code, reduced monitoring of emissions, and intentional adjustment of either emissions or tax records. In some cases, government officials attempt to influence the tax rules themselves to create opportunities for corruption, for example, by constructing overly complex tax structures or employing deliberately vague rules that provide government officials substantial administrative discretion.

9.4.1.2 Designing to minimize noncompliance

Once policy makers understand the avenues of noncompliance, they can use the tax design process itself to minimize the incidence of noncompliance.

To address unilateral noncompliance by entities—in other words, tax evasion—policy makers can first carefully develop the MRV systems described above (section 9.3). A rigorous, systematic approach will provide tax authorities the information they need to enforce the laws.

Other elements in the tax design can also increase compliance. These generally involve a few general principles, such as: (i) keeping the system simple and transparent; (ii) minimizing the rewards for noncompliance; (iii) minimizing the need for discretion by public officials; and (iv) incorporating internal procedures and external accountability to provide checks on corrupt behavior.

These principles can be promoted by the following design practices:

- **Simple design.** Complex tax systems create opportunities to hide information, and to claim unwarranted exemptions. Moreover, complex taxes generally will provide more discretion to tax officials. Jurisdictions where noncompliance is a significant concern can minimize both misreporting and corruption by designing as simple a carbon tax system as possible. For example, upstream and midstream taxes on fuels are generally easy to implement and provide fewer opportunities for misreporting.

- **Uniform rates.** One specific way to design a simple system is to adopt uniform rates across covered entities. Any difference among carbon tax rates would provide an opportunity to evade tax by misreporting the true origin or use of the fuel. For example, where tax rates are different for different sectors, across subnational districts, across fuel types, or among users, misreporting could be encouraged and monitoring can be difficult. Similarly, if the carbon tax rate for households is lower than for commercial units, it could induce unrecorded transfer of fuel from the former to the latter. Moreover, where tax rates are highly differentiated across covered entities, the process of determining exemptions and classifications creates an opportunity for liable entities to bribe officials for favorable treatment. A system that applies the same tax rate to all sources, which is also consistent with cost-effective emission mitigation design, is easier to monitor and enforce and minimizes opportunities for corruption.

- **Transparency.** Generally, transparency in design and implementation of a carbon tax will increase the integrity of the overall system. It is easier for third-party observers to monitor both private and public compliance with the rules when the system is clearly defined and based on simple rules. To increase transparency, governments can provide as few exemptions and exceptions as possible and publicize annual and geographic carbon tax revenue collection data by source and activity. This will increase the accountability of the responsible government agencies.

- **Use of clear emissions proxies.** Carbon emissions can be difficult to measure directly (see discussion of MRV in section 9.3). For many applications, it is easier for governments and third parties to monitor fuel use than emissions. In these cases, adopting a transparent and easy-to-measure proxy for carbon emissions can reduce noncompliance by further promoting transparency. For example, applying the tax to the carbon content of fossil fuels can serve as an effective and simple proxy for CO_2 emissions. Applying that proxy upstream or midstream to fossil fuel production or sales at the oil refineries, natural gas processing plants, coal mines, or electric utilities can further promote compliance by limiting the number of entities that have to be monitored. As discussed in chapter 5, applying this approach to fossil fuels will often also minimize administrative costs.

- **Appropriate design to match institutional and technical capacities.** Some design options (e.g., offset programs, selective exemptions, and differentiated tax rates) will require greater monitoring capacities than others. Jurisdictions with a comprehensive and well-functioning national MRV system can probably apply the carbon tax to a choice of sectors and at different points in the supply chain, while a government whose MRV systems are weak may consider it easier to apply monitoring approaches that limit the need for detailed information about specific activities. This could be achieved, for example, by limiting the tax to fossil fuels (which limits the range of activities that must be monitored) and applying it upstream (which limits the number of entities that must be monitored).

- **Targeting entities regulated by international standards.** For some jurisdictions, a significant part of their emissions might be traced back to multinational corporations (MNCs). Many MNCs are subject to regulations outside of the host country. For example, Organisation for Economic Co-operation and Development (OECD) countries generally have strict rules prohibiting corruption. In jurisdictions where corruption is a significant concern, placing the tax there where the concentration of companies subject to OECD corporate rules is the highest can reduce noncompliance. Similarly, in jurisdictions where stock exchange rules require greater transparency and impose specific ethics standards, applying the tax where there is a relatively large concentration of publicly traded companies can also reduce evasion. By designing the carbon tax to target entities that are subject to penalties beyond the jurisdiction's own provisions, policy makers can encourage compliance.

- **Gradual increase in tax rate.** Although policy makers may decide on a certain carbon tax rate, it can be beneficial to start out with a lower rate and gradually raise it to the desired rate over the course of several years. Where jurisdictions apply the chosen rate right from the beginning, the tax burden may be so sudden for some covered entities that they may be tempted to evade it. In this case, other liable parties that would otherwise be willing to pay the tax may feel forced to evade it as well because they have to compete with tax-evading parties in the market. This creates an undesirable equilibrium. By starting with a lower tax rate, jurisdictions can encourage early compliance and keep liable parties in a better equilibrium, where everyone pays the tax. Early compliance with the lower tax could, in some cases, be "habit forming," so that parties are less inclined to evade taxes once they are raised.
- **Benchmarking.** One of the avenues for noncompliance is smuggling carbon-intensive goods (e.g., fuel or energy-intensive manufactured products such as glass and steel) to avoid paying taxes at the border. One practice that can reduce this particular form of noncompliance is to benchmark the tax rate to reflect the carbon tax of major trading parties and neighboring countries. When countries with strong economic ties have similar tax rates, the benefits of tax evasion by smuggling are substantially reduced.

9.4.2 Minimizing noncompliance through penalties

In addition to carefully designing the carbon tax to minimize opportunities and incentives for corruption and tax evasion, the carbon tax policy must incorporate sufficiently severe and credible penalties to discourage tax evasion. Where governments already have well developed systems for evaluating and sanctioning violations of the tax code, the adoption of a carbon tax may not require any additional measures.

However, jurisdictions should recognize that because the carbon tax could substantially increase the tax liability of some entities, this might increase the temptation to engage in evasion in some cases. Also, in the early stages, some parties might not believe the government intends to vigorously enforce the new tax. For these reasons, policy makers and implementing agencies should work together to review the adequacy of the existing system and consider whether new measures might be warranted.

Some of the most common categories of penalties that can be used for carbon taxes are:

- **Publicizing noncompliance data.** This relatively mild penalty involves simply publicizing the noncompliance status of liable entities. In some cultures and in the case of certain entities (e.g., those with a high sensitivity to public opinion), this "naming and shaming" approach alone may be sufficiently strong to induce compliance.
- **Requiring tax repayments.** This approach requires noncompliant parties to pay all unpaid taxes. Given that the noncompliant party only has to pay what they were liable to pay anyway, make-good requirements do not necessarily comprise a strong disincentive to comply in the first place, especially where there is a fairly good chance of nondetection. Make-good requirements may, nonetheless, be a reasonable option in the case of unintentional noncompliance, for instance, good faith errors in emissions reporting. Moreover, many jurisdictions (e.g., Norway and India) charge interest on late tax payments.
- **Imposing fines and penalties.** Most jurisdictions employ some form of fine for parties that intentionally evade their carbon tax obligations, whether through nonreporting or other evasion tactics. For example, In British Columbia, the Ministry of Finance has been given significant inspection and audit powers, with the ability to assess interest and penalties (ranging from 10–100 percent of the tax amount owed). Generally, when firms consider the potential savings of evading carbon taxes, they will weigh those against the risks and penalties associated with being caught. Hence, the fines imposed should be sufficiently high that firms will not want to risk detection. The value of the fine can be set in proportion to the fines on tax evasion for other taxes in the jurisdiction. A fine may be higher for intentional noncompliance than for unintended noncompliance (resulting from good faith errors). Board members of corporations may also be held jointly and severally liable for unpaid taxes, penalties, and interest. In Ireland, where the carbon tax is assessed on fuel suppliers, the Revenue Commissioners can revoke a trader's license and assess a fine of up to €5,000 for noncompliant entities.
- **Criminal charges.** In severe cases, jurisdictions may bring criminal charges against repeated and egregious offenders, particularly those who have engaged in corruption of government officials. An extension of the criminal charges would be to hold financial and chief executive officers of corporations criminally liable for their corporation's intentional liability. For example, the French government has stated that it could make use of

criminal charges for noncompliant behavior. In Norway, failure to comply with the carbon tax law is subject to fines and up to three months imprisonment.

A typical tax system has a range of potential penalties, with the type and level of the penalty differentiated according to the degree of noncompliance. Overall, penalties must be set at a level such that the benefits of noncompliance do not outweigh its costs (taking into account the likelihood of detection). The level of the penalty should therefore be adjusted according to the scale and frequency of non-compliance and whether noncompliance is deliberate or accidental. For example, the Mexican environmental agency, PROFEPA, can impose a fine of 3,000 days of minimum wage for a violation. If the federal prosecutor finds evidence of falsified data or noncompliance with reporting requirements, he can impose a fine of up to 10,000 days of the minimum wage. For a second violation, the fine can be up to three times the original amount. Violators can also be charged with additional civil and criminal liabilities.

Penalties will only act as a credible disincentive if they are consistently and fully enforced. An advantage of a carbon tax (over, for example, a cap-and-trade scheme) is that governments will have existing rules and institutions for enforcing their tax regime and, where these are functioning well, it can provide a strong basis for safeguarding the integrity of the carbon tax. To ensure proper functioning, tax authorities must be granted sufficient powers to investigate suspected noncompliance with the carbon tax. For example, in British Columbia, the Ministry of Finance is granted audit powers, with the authority to assess noncompliant entities' interest and penalties (ranging from 10 to 100 percent of the tax amount). For the authority to be meaningful though, authorities must have sufficient capacity (training, staffing levels, and budget) to investigate, pursue, and prosecute cases of noncompliance (section 9.2.4).

If MRV is conducted by an entity other than the tax authorities, it is important to ensure that the entity in question has sufficient authority to investigate suspected discrepancies in reporting and the power to apply penalties directly, or advise the tax authority to apply penalties.

It is sometimes suggested that a check by an independent third party would help mitigate collusion between taxpayers and public officials. However, this proposition should be approached with caution, as an independent third party can also be corrupt and simply increase the total amount paid in bribes by tax evaders. To address this possibility, jurisdictions may also assess penalties for collusion or misreporting by third-party verifiers.

The effectiveness of enforcement and penalties is also enhanced by timely application. To this end, the judicial process for determining noncompliance or appealing a noncompliance ruling should be efficient. If the relevant judicial processes are typically slow, governments can consider adopting expedited processes for prosecuting noncompliance with the carbon tax.

Key Considerations

- The scope and design of the carbon tax have major implications for the extent of institutional capacity needed to oversee implementation of the carbon tax. Taxes covering emissions beyond the production and sale of fossil fuels and those that include flexibilities will typically have substantially greater administration needs.
- Coordination is of key importance in the administration of carbon taxes covering multiple sectors or those with links to other programs, such as offset programs or conditional exemptions. Establishing clear procedures and open and regular channels of communication can facilitate smooth implementation.
- Where governments use revenue from the carbon tax to reduce other taxes, this may free up tax administration capacity that can be used to support carbon tax administration.
- MRV of emissions is typically not needed for taxes targeting fuel production and sale, where liabilities are usually based on volumes purchased multiplied by the carbon content of fuels, while taxes targeting other emissions will typically require more complex MRV systems.
- Jurisdictions that want to apply the tax to direct emissions but don't have suitable MRV systems in place may consider applying the tax to fuels, as an interim step, while they develop their MRV arrangements.
- While adopting clear and meaningful penalties is an important deterrent against noncompliance, a well-designed tax that is adapted to local circumstances and administrative capacities can significantly reduce opportunities for noncompliance in the first place.

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PART III

POLICY OUTCOMES

10 EVALUATING POLICY OUTCOMES

At a Glance

Designing and implementing a carbon tax will be new territory for many jurisdictions, and even for experienced policy makers the process is characterized as “learning by doing.” Reviews of program performance and impacts help to assess whether the tax is meeting its objectives, and identify areas for improvement. Governments may also choose to build procedures for adjustments to the policy into the process.

Three types of reviews are helpful in evaluating the performance and impacts of a carbon tax and identifying opportunities for improvement:

- **Impact evaluations assess the performance of the tax and feed into the other reviews.** These are analyses that identify primary indicators and evaluate impacts. Primary indicators may include emissions levels, tax revenue levels, output production, and energy price changes. Relevant impacts may include those on economic growth, social costs, and their distribution, as well as trade effects, technological innovation, and diffusion effects.

- **Comprehensive reviews are designed to amend fundamental elements of the carbon tax.** The results of the impact evaluation can help identify opportunities for structural changes to specific tax design features. Review of key factors such as emissions levels and revenue levels, or major impacts such as economic costs and the burden on low-income households, for example, may lead a jurisdiction to adjust the tax rate or rethink the use of revenue.

- **Regular reviews amend administrative or technical elements of the carbon tax.** They provide an opportunity to review stakeholder and administrator experience regarding factors such as tax administration, reporting, transparency of requirements, and information support systems. These reviews can be scheduled periodically (e.g., annually) or held as needed to respond to new issues such as conflicts with other laws or unanticipated loopholes.

A primary reason to conduct reviews is to identify opportunities for adjustments to the carbon tax program. Various approaches can be taken to manage the modification process, including:

- **Automatic adjustments.** This approach provides a prescribed formula for adjusting specific elements of the tax’s design, such as tying tax rate adjustments to emissions or revenue levels.

- **Administrative adjustments.** Some jurisdictions might choose to vest authority to make minor modifications in the administrating agency. This approach emphasizes the technical expertise of the agency in evaluating the performance of the program.

- **Legislative adjustments.** The legislative branch will in many cases choose to retain the power for modifications of the more fundamental elements of the tax program, or those that are particularly sensitive politically.

In both the review process and management of adjustments to the carbon tax design, policy makers should be aware that covered entities benefit from predictability in their tax liabilities. For this reason, jurisdictions should seek review and adjustment processes that balance the flexibility to respond to experience and changes in circumstances with predictability (to the largest extent possible). Systems with clearly defined processes and responsibilities for review and adjustment will tend to provide “predictable flexibility.”

10.1 INTRODUCTION

An integral part of the carbon tax design process is planning ahead for regular, and in some cases also unscheduled, reviews and revisions of the program as it develops. To get the most benefit from a review process, it can be helpful if policy makers have a clear understanding of the rationale for reviews, the forms they can take, and how they fit in the policy process.

This chapter gives an introduction to the topic and provides guidance on using reviews to continuously improve the carbon tax. Section 10.2 explains the rationale for undertaking reviews and how they fit into the policy-making process. Section 10.3 goes on to describe the main types of reviews, and section 10.4 discusses the link between reviews and changes made to the carbon tax.

10.2 UNDERSTANDING THE RATIONALE OF REVIEWS

Carbon taxes can be complex programs that evolve in an uncertain and dynamic environment. It is impossible to predict how even the best-designed carbon tax will unfold over time. Reviews facilitate the regular evaluation and development of the tax in response to changing policy objectives and circumstances, as well as the evolving experience with the implementation of the tax.

In some cases, reviews of system operations uncover the need for adjustments in the design or administration of the system. In other cases, reviews of the impacts of the system can lead to adaptation of the system. For example, where the carbon tax is having a particularly negative impact on low-income households, the government might adopt new social measures to counter those impacts.

The review process can facilitate adaption and improvement of the carbon tax. Jurisdictions may need to adapt their carbon tax over time for several reasons, including:

- **Complexity.** Carbon taxes are implemented in complex economic and political environments, and the impacts of a tax on different areas—including GHG emissions, public finance system, income distribution, economic growth, and trade and international relations—are often difficult to predict. It is therefore challenging to get the carbon tax "right" from the start and the program will often require adjustments over time. Reviews and evaluations facilitate the process of adaptation in the face of new experience.

- **Administrative performance.** Administration of the tax can also be challenging, particularly where this involves new processes for measuring, reporting, and verification (MRV), administering offsets, or determining eligibility for exemptions and rebates. Conducting performance reviews can facilitate the identification and resolution of unexpected issues that arise in program administration.

- **Uncertainty and "learning by doing."** As indicated in the previous chapters, many of the inputs that policy makers will use to inform carbon tax design—such as estimates of emissions trends, abatement costs, and the demand elasticity of certain sectors—are commonly subject to uncertainty. Reviews can help adapt the carbon tax based on observation of how these factors played out in practice. For instance, where fossil fuel consumption is more responsive to price increases than expected, a government might adopt a more aggressive emission reduction target or lower the tax rate.

- **Changing goals.** A jurisdiction's goals might change over time, either because of changes in the science or changes in international politics. For example, a jurisdiction might increase the ambition of its climate goals in line with the process of updating Nationally Determined Contributions (NDCs) under the United Nations Framework Convention on Climate Change (UNFCCC). Reviews provide an opportunity for adjusting the tax in line with changing goals, while evaluations of tax performance can inform the process of adjusting policy to meet these goals.

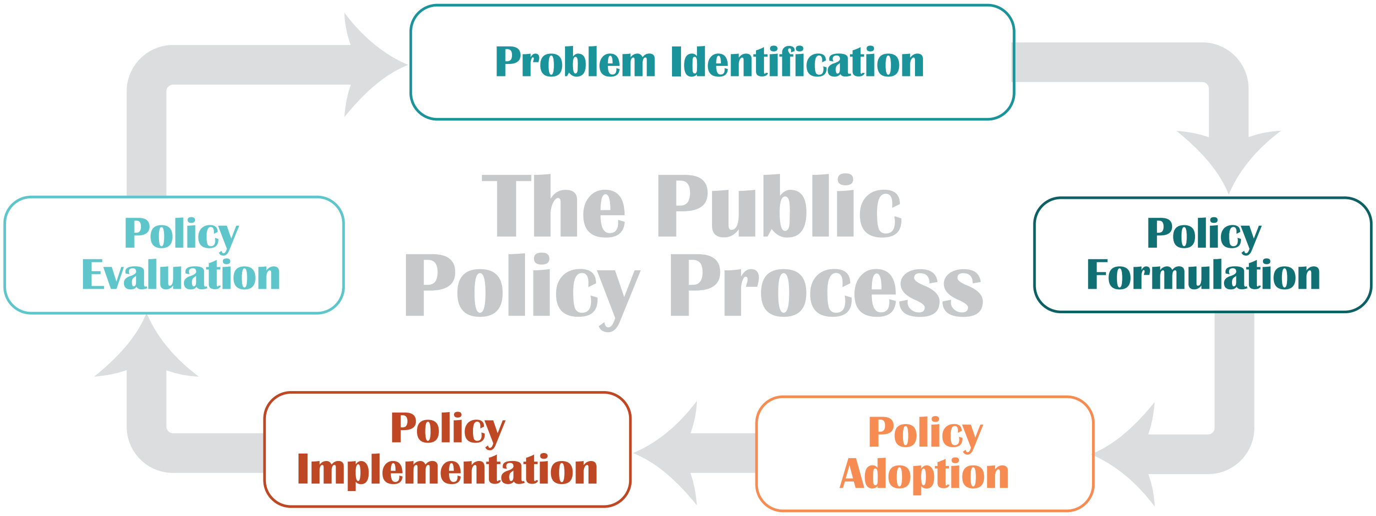
- **Economic fluctuation.** Economic fluctuations can change the impact of the carbon tax on a jurisdiction's economy, as well as on emissions levels and other factors. Reviews can help evaluate the tax's impacts on specific elements of the economy, for example, on particular regions, demographic groups, industries, or international trade.

- **Public support.** The creation of a carbon tax can be a politically sensitive decision. It is therefore important to create and maintain public support for any major initiative. Transparency and a well-documented performance record can help build and sustain political viability.

The evaluation process is often built into the policy process itself. While a carbon tax might start with recognition of the need for the tax and the formulation of policy, the process is cyclical through review and evaluation (figure 23). The information from the reviews can be used to identify additional opportunities for adjustments. If well-defined and well managed, this cyclical process of formulation, implementation, and evaluation can lead to a process of continuous improvement in the policy.

Policy makers undertaking reviews of the carbon tax will need to balance the parallel goals of predictability—important for allowing liable entities and other stakeholders to plan their investments—and flexibility to adapt to changing goals and circumstances. Setting out a clear approach for reviews, evaluations, and adjustments as

Figure 23. The Public Policy Cycle



Source: http://www.thisnation.com/textbook/processes-policyprocess.html.

Note: In the simplest terms, the policy cycle begins by identifying an underlying problem or challenge, such as the need to reduce emissions (chapters 2 and 3). The process moves on through policy formulation (chapters 5 to 7) and adoption and implementation (chapter 8 and 9). As described in this chapter, the cycle is completed with policy evaluation leading to revised problem identification and policy revisions. The cycle repeats periodically.

part of the carbon tax design can promote "predictable flexibility."[66] While the carbon tax itself remains adaptable, the process by which it is evaluated and adjusted can be predictable. Thus, when the review and adjustment process is well-defined, the process is not arbitrary, and parties will perceive greater predictability even if the carbon tax itself might change.

To further enhance predictability, jurisdictions can assign responsibility for the performance assessment to a specific agency, ministry, or department, with the charge to engage a broad range of government entities (including national data collection agencies and statistics offices), private parties, civil society, and academia. A clear assignment of the responsibility enhances accountability, allocation of resources, continuity, and transparency.

10.3 TYPES OF REVIEWS

Clearly specified objectives are needed for reviews to be effective. For carbon taxes, reviews can be tied to one or more of the rationales listed above. Broadly speaking, there are three basic types of review:

- **Impact evaluations** that assess the performance of the tax and support the other reviews
- **Comprehensive reviews** designed to amend fundamental elements of the carbon tax
- **Regular reviews** to amend administrative or technical elements of the carbon tax.

Jurisdictions will generally find it useful to incorporate all three types of reviews in their evaluation processes. As indicated in figure 24, the impact evaluation process involves both a separate review and a critical input for the comprehensive review. Each type of review is considered in more detail below.

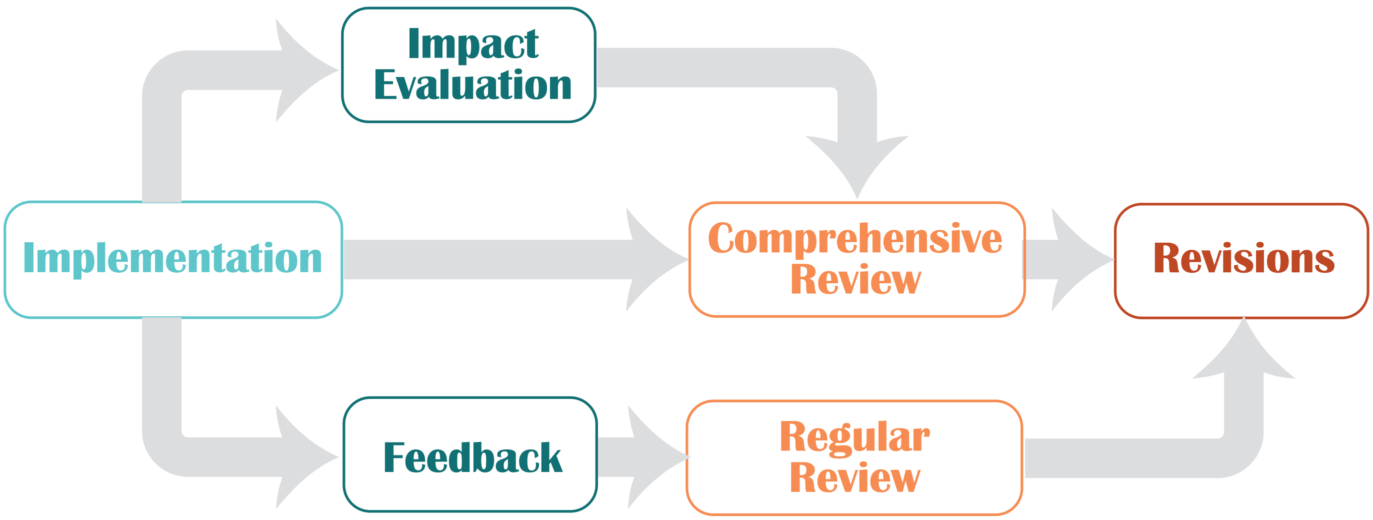
10.3.1 Impact evaluations

The comprehensive and regular reviews described below are specifically aimed at identifying opportunities to improve the carbon tax system by adjusting fundamental elements, rules, and procedures of the carbon tax. By contrast, impact evaluations provide assessments of the social, economic, and environmental effects of the carbon tax. The results of an impact evaluation can be used independently to understand the effects of the carbon tax; they also become important inputs for the other reviews, particularly the comprehensive review.

To prepare for impact evaluations, jurisdictions will need to make several decisions, including how to define the baseline that will serve as the point of comparison for observed impacts, the selection of key indicators and metrics that will be used to evaluate the impacts, and how the

[66] The World Bank Institute (2010) defines "predictable flexibility" as allowing "for timely revision when the underlying social and political circumstances have changed" while being "explicit in defining the conditions under which its terms should be revised." Similarly, among many others, Stern (2008) notes the importance of predictably flexible policy to provide long-term planning while being flexible enough to adapt to changing circum¬stances.

Figure 24. Organization of Reviews



evaluation process itself will be managed. Each of these points is discussed below.

10.3.1.1 Defining the baseline

Evaluations of any type need clearly specified baselines that serve to portray a hypothetical (or "counterfactual") scenario under which the carbon tax was never adopted. The difference between this counterfactual scenario and the observed world can then be used to infer the impact of the carbon tax on selected outcomes. If done prior to the implementation of the carbon tax, the baseline can also help serve as a benchmark from which to measure progress over time. In addition to aiding in the assessment of the results, the establishment of a clear baseline can aid in the comparison of alternative policies that adopt the same baseline. Furthermore, the process of defining the baseline aids in refining data needs and key indicators to monitor.

Defining a baseline can be challenging when policy is uncertain or multiple policies are considered simultaneously. If the policy package accompanying the carbon tax involves other changes to programs or policies that influence carbon emissions levels (e.g., tax revenues as subsidies for low-emission investments), the baseline can be set to either assess the impact of the collective policies or just the carbon tax component. Consequently, governments need to carefully consider what it is they want to measure when deciding how to calculate the baseline.

To illustrate, from 1990 to 2012, Australia's emissions remained approximately the same, despite a doubling of the size of its economy over that time. To understand the underlying drivers, particularly with respect to electricity, the country relied on a 2013 report in which the baseline had simply been estimated by projecting the growth of emissions after 2005 based on the growth rate from1985 to 2005. The study not only estimated observed total emission reductions relative to that baseline, but also estimated the contribution that various factors—for example, efficiency programs, industrial closures, and renewable energy—had made to the reduction. It concluded that price effects, including the carbon tax, accounted for 14 percent of the reduction in emissions (Climate Change Authority, Australian Government, 2014).

10.3.1.2 Identifying key indicators

Jurisdictions can tailor impact evaluations to their specific circumstances and policy goals. Some primary indicators—those that can be directly observed or calculated with little or no modeling—of impacts might include the following:

- **Emission levels.** For most jurisdictions, reducing emissions is among the main objectives of the carbon tax. Tracking emissions levels in covered sectors or activities over time provides insight into progress made toward meeting abatement targets and how the tax is contributing to meeting them. Information on emissions in covered sectors is often already gathered as part of the tax administration process, for example, where records of the production or sale of fossil fuels are collected for tax or other monitoring purposes. However, separating the effect of the carbon tax from the effect of other factors (e.g., economic growth, technology development) can be challenging (see discussion of baselines above). For example, a Swiss assessment of the country's carbon tax found the levy was highly efficient in emission reductions. Between 2008 and 2013, the total cumulative reduction effect was estimated at 2.5–5.4 million metric tons of carbon dioxide equivalent (tCO_2e) (Ramer, 2016). Early evaluations of Australia's Green Energy Package, which included the carbon tax, suggested the policy had resulted in a 5 percent decrease in CO_2 emissions between 1996 and 2005 (Danish Energy Agency, 2000).

- **Revenue raised.** Whether or not raising revenue is a primary goal of the carbon tax program, it is an important element of the impact. As discussed in chapter 5, if the tax rate is high enough to significantly lower emissions, it is likely to raise a significant amount of revenue. For example, in France, the carbon component of the Domestic Consumption Taxes is expected to generate close to €4 billion in revenues. That can have a major impact on spending or on the broader tax system. This information is tracked as part of the tax collection and general budgeting process.

- **Energy prices.** Because energy prices can be a politically charged issue, jurisdictions might choose to monitor these closely. Because of the natural volatility of energy prices, however, identifying causality with carbon tax rates can be a particular challenge with this metric.

The evaluation can also track secondary indicators for the carbon tax. Any of the ex ante policy criteria (e.g., the FASTER principles described in chapter 3) or concerns could be important performance measures. For example, jurisdictions might seek to design carbon taxes that are cost-effective and fair, and bring economic improvements. Generally, these secondary indicators will require more involved program evaluation methods and interpretation. Potential indicators include:

- **Cost-effectiveness.** One of the primary advantages of a carbon tax is that it is expected to induce cost-effective emission abatement. If businesses and consumers are not adopting abatement measures that are cost-effective given the carbon tax, policy makers might consider additional measures, such as public education initiatives, to address the barriers to their adoption. For example, if there is evidence that commercial property operators are not reducing their cooling loads or households are not shifting to more efficient appliances in the face of increased energy costs, the government might consider developing programs to raise awareness of energy efficiency options. Similarly, if electricity generators are not shifting their generation toward low-carbon fossil fuels and renewable energy, the jurisdiction might investigate whether there are market or regulatory impediments to cost-effective adaptation to the carbon price signal.

- **Tax impacts by income group and geographic region.** Many jurisdictions are particularly concerned about the potential impacts of a carbon tax on vulnerable parts of society. Similarly, some regions of the jurisdiction (e.g., those with heavy manufacturing industry or coal-powered electricity plants) might experience higher impacts than others. The actual impact will be context-specific and can be evaluated in a periodic assessment.

- **Revenue impacts.** Jurisdictions may want to understand the impact of the carbon tax revenue on their economy, social welfare, or both. For example, if the revenue is used to reduce other taxes, both policy makers and the public might want to understand how much taxes have been reduced and how the benefits of those reductions are distributed across income groups and industries.

- **Technological innovation and deployment.** A significant carbon tax will induce changes in consumption and investment decisions, which can in turn lead to technological innovation and deployment. For some jurisdictions, this could be a primary motivation for the carbon tax, as it supports sustainable development. For example, Sweden's use of heating fuel for households and services has decreased dramatically since the introduction of that country's carbon tax. At the same time, the production and use of biofuels, which are exempted from the tax, have increased significantly (Ludovino Lopes Advogados, Climate Focus and WayCarbon 2014).

- **Leakage and impacts on trade.** As discussed in chapter 7, many industries have expressed particular concern that they might be disadvantaged by the imposition of a carbon tax. In jurisdictions where this is a special concern, the government could conduct an ex post evaluation of leakage and trade impacts.[67] For example, in British Columbia, there had been widespread public concern about the impacts of the carbon tax on international competitiveness, but ex post analysis found that only a small percentage of industries was actually vulnerable (Sustainable Prosperity, 2012).

- **Impact on the economy.** Jurisdictions are often concerned about the carbon tax's impact on their economic growth. While evaluating the impact of a carbon tax on the economy can be challenging, some jurisdictions may find this exercise informative.

10.3.1.3 Managing the evaluation

Once indicators have been agreed, each indicator should be evaluated in a two-step process: data gathering and assessing impacts.

1. **Data gathering.** To conduct a meaningful ex post evaluation of a carbon tax, jurisdictions will need to gather sufficient and reliable data. Some of the important data are gathered as part of the tax administration process or regular national data monitoring processes, for example, tax revenues, energy prices, trade activity, wages, and employment figures. The MRV system will meanwhile gather data on emissions, at least for the covered sectors.

   Some of the analyses, however, will require additional data, in some cases at the household or company level.

[67] See section 7.3 for a discussion of modeling approaches to evaluate leakage potential and impacts.

Prior to implementation of the carbon tax, therefore, it can be useful for policy makers to assess whether established surveys, censuses, and reporting systems will provide the data needed to support the types of evaluation that the jurisdiction will require. This will serve to determine whether the additional data can be gathered by modifying existing data collection mechanisms or entirely new approaches are needed.

2. **Assessing impacts.** Assessing the impact of the carbon tax can be more challenging because it requires distinguishing the effect of the tax itself from the effect of other factors. For example, if a jurisdiction observes declining carbon emissions following implementation of a carbon tax but wants to understand if the tax is responsible for the decline, it must first control for the influence of all other factors such as changes in international energy prices, autonomous improvements in technology, and changes in Gross Domestic Product (GDP).

Most of the indicators listed above will require substantial modeling efforts. Chapter 4 describes a broad range of modeling approaches. For this impact evaluation, the economy-wide approaches, particularly general equilibrium models, will probably be the most useful. These approaches capture both direct and indirect impacts of the carbon tax and are particularly useful for assessing distributional effects on different income classes, the impact on the economy, leakage, and the impact on trade.

Econometric studies may also be useful for assessing the effect of the tax on covered entities. These studies, often referred to as "natural experiments," compare the behavior of covered entities before and after implementation of the tax or, alternatively, the behavior of firms covered by the tax with that of firms that are not covered.

In practice, much of the ex post impact evaluation of carbon taxes has been conducted by academics, research groups, and consultants. For example, Australia's assessment of the role that its carbon tax played in substantially lowering its emissions intensity was based on ex post analysis of relevant academic studies and consulting reports. In part, this is because building and applying the complex economic models required is a highly specialized skill that many governments do not have. However, these independent analyses are still available to inform the comprehensive review. They may even have greater credibility if they are conducted outside the direct control of the government. Jurisdictions can encourage this outside analysis by budgeting research funds and providing grants for evaluative studies. It is possible, however, that as the carbon tax revenues become a significant portion of national budgets, jurisdictions may choose to develop and maintain an internal modeling capacity.

10.3.2 Comprehensive reviews

Several of the factors listed in section 10.2—for instance, complexity, uncertainty, changing goals and targets, shifts in public support, and economic fluctuations—may make it necessary to adjust certain elements of the carbon tax from time to time. Providing for regular, clearly defined, comprehensive reviews can add predictability to this process of evaluation and adjustment.

Jurisdictions that provide for regular comprehensive reviews could include the following performance and impact factors:

- Review of the current tax rate in light of objectives for revenue and emissions levels. Such a review could take into account a number of factors, among others, trends in revenue and emissions levels, new technologies, macroeconomic developments, international financial developments, and the effectiveness of other climate policy initiatives.
- Evaluation of compliance costs, leakage, and international competitiveness.
- New developments in measuring, reporting, and verification (MRV) practices.
- Review of the extent to which the tax has affected behavior, technology diffusion, and investments relative to other factors such as other climate policies, economic growth, and prevailing energy prices.

The comprehensive review can also provide an opportunity to augment public understanding and support. A transparent, competent, and comprehensive review assures stakeholders that the jurisdiction is carefully considering the full impacts of the program as well as opportunities for adjustments.

To engender credibility, the comprehensive review process can involve individuals, organizations, and government units with recognized competence in the field of climate policy, economics, finance, social processes, and governance. The process will also be more credible if the participants are generally regarded as objective and nonpolitical. To this end, jurisdictions might consider having the tracking and evaluation done by an agency other than the unit that administers the tax. For example, in Australia, entities were required to report their GHG emissions to the Clean Energy Regulator (Walters and Martin 2012), while the Climate Change Authority was responsible for reviewing the results of the Clean Energy Package and making recommendations to Parliament (Environmental Defense Fund, CDC Climat Research, Caisse des Dépôts Group, and IETA, 2015).

The frequency of the comprehensive reviews will vary according to the needs and capacities of the jurisdiction. For example, where there is considerable uncertainty in setting the tax rate, where the economic climate is particularly unstable, or where political support for the carbon tax needs to be bolstered, jurisdictions might choose to conduct more frequent comprehensive reviews.

10.3.3 Regular reviews

Where comprehensive reviews focus on the overall impacts of the carbon tax and progress toward policy goals, regular reviews are aimed at identifying the performance of the carbon tax from an administrative and legal perspective. Regular reviews provide an opportunity to assess a number of elements of the carbon tax, including:

- **Stakeholder experience.** Jurisdictions may particularly examine whether the requirements are clear, the procedures easy to follow, and the information accessible.
- **Implementing agency experience.** Jurisdictions can draw on observations from personnel in the implementing agency to identify opportunities for improvement of the system.
- **Compliance rates.** It is important to periodically assess whether liable entities are accurately reporting and meeting their obligations. Jurisdictions can use the results of regular audits to assess trends in compliance and determine whether additional measures are needed.

While these elements may be the subject of regular review, jurisdictions may also need to conduct urgent reviews to address unexpected, new developments such as:

- Unanticipated loopholes in the carbon tax;
- Extraordinary circumstances, which could result in liable entities unintentionally becoming noncompliant;
- Conflicts with other laws and regulations.

Where comprehensive reviews are generally most credible when conducted by independent, subject-matter experts, the regular reviews can be managed by government administrators and legal experts. At the same time, the process can often benefit from seeking input from stakeholders.

10.4 ADJUSTING CARBON TAX PROGRAMS FOLLOWING REVIEW

The purpose of the review process is to maintain the effectiveness and efficiency of the program and, as part of this, to inform jurisdictions of the need for adjustments. Table 26 provides several examples of the types of observations that might arise from a review, and the types of adjustments a jurisdiction might make in response.

The way jurisdictions use the results of reviews is also important. Jurisdictions will enhance predictability if they

Table 26. Examples of Relation between Performance and Impact Factors and Potential Carbon Tax Adjustments

FACTOR	EXAMPLE OBSERVATION	EXAMPLE ADJUSTMENTS IN CARBON TAX DESIGN
Emission levels	Emission levels are above target levels	Increase carbon tax rate
Revenue collected	Revenue is above targeted level	Lower other taxes, increase spending, lower carbon tax rate
Economic cost	Economic costs of carbon tax are higher than expected	Adopt measures to reduce transaction costs and promote information diffusion, adjust emission targets, or lower carbon tax rate
MRV techniques	New methods of measurement lower the cost of MRV in untaxed sectors/sources	Expand coverage of tax to include additional entities
Technology development	Cost of renewable energy technologies has declined more rapidly than expected	Decrease carbon tax rate or increase abatement target
Technology diffusion	Liable entities have not adopted energy conservation practices as rapidly as expected	Organize outreach campaigns to communicate options to liable entities
International commitments	Increase in ambition of Parties to Paris Agreement following five-year reviews	Increase carbon tax rates, expand coverage of carbon tax, use revenue to achieve greater emission reductions, and invest in greater technology diffusion
Leakage	Trade partners have adopted similar carbon tax rates	Reduce exemptions or other leakage mitigation measures
Impacts on vulnerable groups	Low-income households incurred higher economic costs than anticipated	Adjust other tax rates so they are more progressive, adopt support schemes targeted at low-income families

specify not only the type and timing of reviews, but also if and how the information will be used to adjust the design of the program. This is particularly relevant for the comprehensive review, which could lead to changes in major elements such as the tax rate, tax base, and use of revenue.

Basically, the review and evaluation feedback can be linked to adjustments in the carbon tax through three approaches:

- **Automatic adjustments.** For some elements of the carbon tax, it is possible to link prescribed adjustments directly to the results of the review. For example, the initial design of the carbon tax program could include an adjustment formula that incorporates factors such as progress in meeting emission reduction targets (raising the tax rate if GHG abatement is falling behind schedule), revenue levels, inflation (linking the tax to some measure of inflation such as the CPI), exchange rate shifts, and GDP growth. The advantage of this approach is that it enhances predictability and moves the adjustments outside the realm of political influences.
- **Administrative adjustments.** Policy makers can delegate responsibility for adjusting certain carbon tax design features to specific agencies or executives in the government. Under this approach, the responsible individuals interpret the results of the review and any associated recommendations in the light of professional judgment before making adjustments in the tax. This approach is particularly useful for adjustments that are less amenable to formulaic determination, such as those involving administrative procedures, appeals processes, MRV programs, and conflicts with other statutes and programs. Administrative discretion has the advantage of adaptability in the face of complex decisions, but still shields the process from political influence.
- **Legislative adjustments.** Policy makers can also stipulate that adjustments to the carbon tax require legislative approval. This places control directly with elected representatives. Jurisdictions might consider some potential adjustments (e.g., coverage, exemptions, revenue spending) so closely related to either policy goals or personal rights that they choose to reserve these decisions for the legislature.

As discussed in section 10.2, the ideal adjustment mechanism will recognize the tension between the need for flexibility and the need for predictability. Generally, systems that are more bound by formula and prescription are more predictable but less flexible. Review and adjustment processes that are more open to political influence can be more flexible but less predictable. Each jurisdiction will need to balance these two aspects as it defines the aims, procedures, and responsibilities for its carbon tax review and adjustment process.

Key Considerations

- Implementing a carbon tax is often characterized by “learning by doing.” Undertaking regular evaluations and reviews helps keep track of whether the tax is meeting its objectives and identify areas for adjustment and improvement.
- Clearly defining the aims of the review is crucial for determining what should be assessed and how it should be designed. Policy makers should have a clear idea of what they expect to learn from the evaluation and what outcome they expect from the review.
- Effective evaluations depend on the availability of consistent and reliable data. Jurisdictions that design their review processes concurrently with the carbon tax itself can identify data needs early on and may be able to build data gathering into the administration of the tax.
- In defining the scope and frequency of reviews, most jurisdictions will seek to balance the need to retain flexibility to modify the program over time with the need to provide the predictability that allows liable entities to make long-term investment decisions.

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APPENDIX A: GLOSSARY OF TERMS

Abatement	The reduction of greenhouse gas emissions, either in absolute terms or relative to a baseline or other metric.
Annex I Party	A State Party included in Annex I to the UNFCCC, which includes all countries considered to be developed economies or economies in transition at the time of adoption.
Baseline	A hypothetical projection of the level of GHG emissions over a given period of time in the absence of a given policy or project.
Benchmark	A point of reference for a comparison; a comparison of performances or standards.
Carbon dioxide equivalent (CO_2e)	The universal unit of measurement to indicate the global warming potential (GWP) of each of the seven GHGs covered by the United Nations Framework Convention on Climate Change, expressed in terms of the GWP of one unit of carbon dioxide.
Carbon leakage	Where a mitigation policy causes a reduction in emissions in the jurisdiction where it is implemented but inadvertently leads to an increase in emissions in jurisdictions without equivalent policies.
Counterfactual	What would have happened in the absence of a policy or action. In the process of policy evaluation, the counterfactual is used to develop the baseline for evaluating the impact of a policy, project, or program action.
Deadweight loss	An economic cost to society caused by market inefficiencies, often due to a government policy intervention such as a price control or tax, but which also arises when production and consumption activities have externalities.
Direct tax	A tax where the taxpayer makes the payment directly to the revenue authorities. Personal income and property taxes are common examples of direct taxes.
Discount rate	The rate at which future costs and benefits are discounted relative to current costs and benefits. Generally, costs and benefits that occur in the future are valued less high than similarly sized current costs and benefits. In valuing future costs or benefits, a higher discount rate lowers the value of costs or benefits that occur in the future.
Distributional impacts	Distributional impacts refer to the way the economic burden of a policy action falls on differently situated individuals. Most commonly, they refer to how a policy action (such as a tax) affects different income groups. However, other distributional impacts of interest can include region, economic sector, age, and other demographic characteristics.
Economic efficiency	The optimal allocation of resources; the use of resources in their highest valued use.
Elasticity of demand	The elasticity of demand is a measure of how responsive the amount of a good demanded is to changes in price. For highly elastic demand functions, a small percent change in the price of a good will lead to a larger percent change in the amount demanded.

Emissions factor	A factor that converts activity data into GHG emissions data (e.g., kg of CO_2e emitted per liter of fuel consumed, kg of CO_2e emitted per kilometer traveled).
Emission mitigation	Actions taken to limit the accumulation of GHGs in the atmosphere. These can be direct, as in reducing fossil fuel consumption or capturing and storing carbon dioxide before it is emitted. They can also be indirect, as in protecting and expanding the stock of carbon in forests and agricultural soils.
Emissions Trading System/ Scheme (ETS)	Also known as a cap-and-trade system, an ETS sets a desired maximum ceiling for emissions (or cap) and lets the market determine the price for keeping emissions below that cap. To comply with their emission targets at the lowest possible cost, regulated entities can either opt for internal abatement measures, acquire allowances, or reduce their emissions, depending on the relative costs of these options.
Ex ante	Before the event; in the case of policy analysis, assessing the expected results of a policy in advance of its implementation.
Exemptions	The amount of a tax that liable entities can deduct from their tax liability.
Ex post	After the event; in the case of policy analysis, an investigation of the observed results following implementation of a policy.
Externality	The positive or negative effect that a market transaction has on other parties that were not involved in that transaction. The classic example of a negative externality is pollution deriving from emissions.
Fugitive emissions	Emissions that are not physically controlled but result from intentional or unintentional releases of GHGs. They commonly arise from the extraction of coal and natural gas, and the processing, transmission, storage, and use of fuels and other chemicals. Leakage can sometime occur through joints, seals, packing, or gaskets.
Greenhouse gas (GHG)	Both natural and anthropogenic, GHGs trap heat in the Earth's atmosphere, causing the greenhouse effect. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary GHGs. The emission of GHGs through human activities (such as fossil fuel combustion and deforestation) and their accumulation in the atmosphere are the main factor responsible for climate change.
Indirect tax	A tax where the ultimate taxpayer is not the person that makes the payment to the revenue authorities. VAT and excise taxes, which are collected from consumers by retailers, are common examples of indirect taxes.
Jurisdiction	For the purposes of this Guide, jurisdiction refers to the geographic area within which a carbon tax is administered. Jurisdictions can be subnational, national, or multicountry regions.
Marginal costs	The additional total cost associated with increasing the production of a good or service by one unit, the cost of the last unit produced.
Marginal Cost of Public Funds (MCPF)	The cost to society of raising government revenue by one unit (e.g., euro or yen). The MCPF is generally expected to be greater than one because the act of taxing market transactions (like labor and investment) distorts efficiency-promoting price signals.
Nationally Determined Contribution (NDC)	The individual GHG emission mitigation and adaptation contributions developed by and agreed to by Parties to the Paris Agreement.

Non-Annex I Party	All State Parties to the UNFCCC that are not included in Annex I.
Offset	A unit representing emission reductions (or removals) that have taken place outside of the scope of a carbon tax or ETS program, and have been verified in accordance with a recognized offset standard.
Process emissions	Emissions generated through manufacturing processes, such as, for example, CO_2 that is released during the breakdown of calcium carbonate ($CaCO_3$) in cement manufacturing.
Progressive impacts	A tax has a progressive impact when high-income households pay a higher percentage of their income for the tax than do low-income households. For example, Income taxes with marginal rates that increase with income level are generally progressive.
Rebate	An amount of tax paid that is later returned to the taxpayer by the government.
Regressive impacts	A tax has a regressive impact when low-income households pay a higher percentage of their income for the tax than do high-income households. Taxes on necessities tend to be regressive because necessities make up a larger share of low-income household budgets than of high income-income household budgets.
Revenue neutrality	An approach to changes in tax structures that leaves the total government revenue unchanged. Any increase or decrease in tax rates in one area of the tax code is offset by increases or decreases in other areas, leaving the level of overall government revenue unchanged.
Social Cost of Carbon (SCC)	An estimate of the costs of damages—environmental, economic, health, and social—associated with the release of one tCO2e. Often, this figure is tied to a particular year and varies year-to-year (and is generally believed to climb over time), and used for purposes of public policy formulation.
Target-baseline carbon tax	A carbon tax under which liable entities only pay for the level of their covered emissions above a given baseline or benchmark.
Verification	The assessment of the reliability, completeness, and accuracy of emissions-related information submitted by reporting entities.
Zero-baseline carbon tax	A carbon tax under which liable entities pay for all their covered emissions. Most existing carbon taxes are zero-baseline taxes.

ANNEX 4A: EXAMPLE ECONOMETRIC AND HYBRID MODELS OF CARBON PRICING

Country/ state/ province and year of study	Abatement Model type (Name)	Tax rate (USD/tCO_2e emissions) in 2015 value	Tax base	Emission reduction	Effect on economy	Pros-pective (P)/ ret-ro-spec-tive	Government revenue (2015 value)
Japan (Pollitt et al. 2014)	Hybrid econometric model (E3MG model)	US$88.79	CO_2	10% reduction (2010–20)	0.29% increase in GDP	P	Recycle revenue by lowering other taxes, that is, income tax and corporation tax
		US$205.77		15% reduction (2010–20)	0.50% increase in GDP		
		US$592.62		25% reduction (2010–20)	0.82% increase in GDP		
United Kingdom (Dagou-mas and Barker 2010)	Hybrid econometric model (E3MG model)	US$20–46	CO_2	40% reduction (1990–2050)	US$107.63–254.43 billion increase (2015 price)	P	Recycle revenue to subsidize energy sector investments
		US$88–176		60% reduction (1990–2050)			
		US$332–489		80% reduction (1990–2050)			
Japan (Nakata and Lamont 2001)	Hybrid partial equilibrium model (META.Net)	US$277.76	CO_2 from energy sector	20% reduction	Not available	P	US$97.98 billion
Japan (Goto 1995)	Hybrid dynamic CGE model (GDMEEM)	US$326.69	CO_2	Stabilize CO_2 emission at 1990 level in 2020	-0.11% GNP change	P	US$21.76 billion
		US$290.15			Add additional US$122 billion GNP		Recycled to invest energy-efficient technologies
EU-11 (Barker and Kohler 1998)	Dynamic econometric (E3ME)	US$61.52	Carbon content in energy products	10% reduction (1999–2010)	+1.4% GDP change	P	These duties are tax-revenue-neutral via reductions in employers' contributions to social security.
United States (Shapiro et al 2008)	Hybrid (NEMS, National Energy Modeling	US$28.15 (2015) (tax rate increases about US$1.80 each year)	CO_2	30% reduction (2010–30)	0.8% GDP change	P	US$341.70 billion (2015 value) by 2030. Recycle 90% in rebates on payroll taxes or their equivalent in payments to households. The remaining 10% would be used to support energy and climate-related research and development, and new technology deployment.

Note: tCO_2e = metric ton of carbon dioxide equivalent; tCGE = Computable General Equilibrium; GDP = Gross Domestic Product; GNP = Gross National Product

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ANNEX 4B: EXAMPLE CGE MODELS OF CARBON PRICING

Country/ state/ province and year of study	Abatement Model type (Name)	Tax rate (USD/tCO_2e emissions) in 2015 value	Tax base	Emission reduction	Effect on economy	Pros-pective (P)/ ret-ro-spec-tive	Government revenue (2015 value)
United	Hybrid partial equilibrium model (META.Net)	US$277.76	CO_2 from energy sector	20% reduction	Not available	P	US$97.98 billion
Ireland (Wissema and Dellink 2007)	CGE with detail in tax and energy use	US$15.94–US$23.91 Carbon tax	CO_2 from fossil energy	25.8% reduction by 2012 compared to 1998 levels.	0.3% welfare reduction	P	Recycle the revenue by lowering other taxes, which may further reduce welfare loss in the model
		US$55.78–US$63.75 Uniform tax			0.9% welfare reduction		
China (Guo et al 2014)	CGE	US$2.74	CO_2 from fossil energy	5% reduction (2010–20)	0.15% real GDP reduction	P	1.5% Increase
		US$5.82		10% reduction (2010–20)	0.32% real GDP reduction		2.08% Increase
		US$12.91		20% reduction (2010–20)	0.75% real GDP reduction		0.36% Increase
		US$21.02		30% reduction (2010–20)	1.33% real GDP reduction		5.60% Decrease
Russia (Orlov and Grethe 2012)	CGE (STAGE)	US$6.19-US$12.39	CO_2 from fossil energy	10% reduction (time unspecified) (158.61 million tCO_2e emissions)	0.23% welfare increase (perfect competition)	P	US$895 Million (2015 Value) in Gov. Tax Revenue
					0.16% Losses (Cournot Oligopoly blocked Entry & Exit)		-US$1135 Million (2015 Value) in Gov. Tax Revenue
					0.30% Losses (Cournot Oligopoly free Entry & Exit)		-US$1158 Million (2015 Value) in Gov. Tax Revenue
UK (Edwards and Hutton 2001)	CGE	US$66.81	CO_2	20% reduction (1992–2010)	0.00% GNP change	P	Revenue recycled via reduction in other taxation[4].
		US$67.14			-0.08% GNP change		
		US$67.47			-0.03% GNP change		
		US$66.60			0.17% GNP change		
		US$69.02			0.18% GNP change		
		US$67.05			0.03% GNP change		

Country/ state/ province and year of study	Abatement Model type (Name)	Tax rate (USD/ tCO_2e emissions) in 2015 value	Tax base	Emission reduction	Effect on economy	Pros- pective (P)/ ret- ro-spec- tive	Government revenue (2015 value)
West Germany (Bohringer and Rutherford 1997)	Static CGE	US$62.60	CO_2 from fossil energy	20% reduction (1990–2005)	US$16.97 billion welfare decrease	P	Carbon tax revenue: 4.6% of labor and capital tax revenue in 1990
		US$87.01			US$19.42 billion welfare decrease		Carbon tax revenue: 5.5% of labor
		US$66.84			US$15.92 billion welfare decrease		Carbon tax revenue: 5.0% of labor and capital tax revenue in 1990
China (Zhang 1998)	CGE	US$37.56	CO_2	20% reduction (1990—2010)	-1.52% GNP change -1.08% welfare change	P	4.52% increase (tax retained by gov.)
		US$73.02		30% reduction (1990–2010)	2.76% GNP change -1.75% welfare change		7.33% increase (tax retained by gov.)
		US$37.56		20% reduction (1990–2010)	-1.47% GNP change 0.23% welfare change		-1.47% GNP change 0.23% welfare change
		US$73.02		30% reduction (1990–2010)	-2.18% GNP change -0.25% welfare change		-2.18% GNP change -0.25% welfare change
Germany & India joint (Bohringer et al. 2003)	Static CGE	US$108.81 (Germany impose tax alone)	GHGs for Germany	25% reduction (1990–2005)	-0.47% welfare change Germany	P	Revenue-neutrality: recycle revenue from environmental taxes through cuts in labor costs
		US$54.40 Joint implemen- tation with India	Indian Electri-city sectors		-0.26% welfare change Germany; 2.49% welfare change India		
Australia (Siriwar- dana 2011)	Static CGE (ORANI-G)	US$15.48	GHGs	10.05% reduction (2000–20)	-0.35% GDP change	P	US$4.5 billion (1st year)
		US$23.74		12.44% reduction (2000–20)	-0.68% GDP change		US$6.58 billion (1st year)
		US$30.97		15.18% reduction (2000–20)	-0.88% GDP change		US$8.09 billion (1st year)
Australia (McDougall 1993)	Static CGE (ORANI-G)	US$43.51	CO_2 from fossil fuels	20% reduction (1988–2005)	-0.9% GDP change (after two years of implemen- tation)	P	US$13.92 billion (1991-1992) Recycled to reduce income tax

Country/ state/ province and year of study	Abatement Model type (Name)	Tax rate (USD/ tCO_2e emissions) in 2015 value	Tax base	Emission reduction	Effect on economy	Pros-pective (P)/ ret-ro-spec-tive	Government revenue (2015 value)
China (Lu et al 2010)	Dynamic CGE model (THCGE -DR)	US$33.63	CO_2	11.96% reduction	-0.74% GDP change	P	10.37% increase in government consumption, based on fiscal revenue from carbon tax
					-0.71% GDP change		0.96% increase in government consumption (Recycled to enterprise as subsidies)
					-0.67% GDP change		0.76% increase in government consumption (Recycled to households as subsidies)
Norway (Aasness et al 1996)	Dynamic CGE (MSG-EE)	US$130.23	CO_2	Stabilize CO_2 emissions at 1990 level in 2020	-0.66% GNP change	P	Not reported
Indonesia (Yusuf and Resosu-darmo 2007)	Static CGE (ORANI-G)	US$42.19	CO_2 from fossil fuel	Stabilize CO_2 emissions (time unspecified)	-0.04% GDP change	P	Fiscal surplus scenario
					-0.02% GDP change		Fiscal neutral: recycled back to reduce ad valorem sales taxes of all commodities
					-0.03% GDP change		Fiscal neutral: recycled back as a uniform lump-sum transfer to all households
Canada (Hamilton and Cameron 1994)	CGE, I/O, and micro simulation (SPSD/M)	US$27.70	CO_2 from fossil fuel	Stabilize CO_2 emission at 1990 level in 2000	-0.5% real GDP change	P	Transferred to household as a lump sum
India (Fisher-Vanden et al 1997)	CGE (SGM)	US$185.21 on average	GHGs from fossil fuels	Stabilize carbon emissions at 1990 level (timeline unspecified)	-6.3% GDP change by 2030	P	Recycled back to the household sector as additions to personal income.
		US$26.98 on average		Stabilize carbon emissions at two times the 1990 level	-2.9% GDP change by 2030		
South Africa (Devarajan et al 2011)	Static CGE	US$16.39	CO_2	15% reduction	-0.5% real GDP change	P	Transferred to household as a lump sum
Spain (Laban-deira et al 2004)	Static CGE	US$27.15	CO_2	7.7% reduction (1985–1995)	-0.7% GDP change US$564 million increase in social welfare	P	Revenue recycled to reduce other distortionary levies.

Country/ state/ province and year of study	Abatement Model type (Name)	Tax rate (USD/ tCO_2e emissions) in 2015 value	Tax base	Emission reduction	Effect on economy	Pros-pective (P)/ ret-ro-spec-tive	Government revenue (2015 value)
Japan (Ahammad et al 2004)	Dynamic CGE (GTEM)	US$10.88	GHGs from fossil fuels	13.5% increase (2005–2010)	-0.04% GDP change	P	Revenue recycled to invest in energy efficient technologies
		US$143.91		2.6% reduction (2005–10)	-0.58% GDP change		Revenue recycled to consumers through income tax cuts or used to increase government spending
U.S. (Cai 2012)	Dynamic CGE (G3)	US$18.33 (2015) (4.0 real increase tax rate)	CO_2 from fossil fuels	11% reduction (2012–30)	-0.4% GDP change	P	US$202.34 billion (2015 value)
U.S. (Paltsev et al 2008)	Dynamic CGE (EPPA, Emissions Prediction and Policy Analysis)	US$49.76 (2015) (4.0 real increase tax rate)	GHGs	50% reduction (1990–2050)	-1.45% welfare change	P	US$593.45 billion (2015 value) by 2050
U.S. (Rausch and Reilly 2012)	Dynamic CGE (USREP, U.S. Regional Energy Policy)	US$22.33 (2015) (4.0 real increase tax rate)	CO_2	19% reduction (2015–30)	0.02% welfare change	P	Recycled to tax relief or other social programs
U.S. (Rausch et al 2010)	Dynamic CGE (USREP - U.S. Regional Energy Policy)	US$29.93 (2015) (4.0 real increase tax rate)	GHGs	25% reduction (2015–30)	-1.60% welfare change by 2050	P	US$305.54 billion (2015 value) by 2030

Note: tCO_2e = metric ton of carbon dioxide equivalent; tCGE = Computable General Equilibrium; GDP = Gross Domestic Product; GNP = Gross National Product

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