15 Carbon Pricing and Emissions Markets in Practice

Key Messages

Both tax and trading can be used to create an explicit **price for carbon;** and regulation can create an implicit price.

For all these instruments, **credibility, flexibility and predictability are vital to effective policy design.**

A lack of credible policy may undermine the effectiveness of carbon pricing, as well as creating uncertainties for firms considering large, long-term investments.

To establish the credibility of carbon pricing globally will take time. During the transition period, governments should consider how to deal with investments in long-lived assets which risk locking economies into a high-carbon trajectory.

To reap the benefits of emissions trading, deep and liquid markets and well designed rules are important. Broadening the scope of schemes will tend to lower costs and reduce volatility. Increasing the use of auctioning is likely to have benefits for efficiency, distribution and potentially the public finances.

Decisions made now on the third phase of the EU Emissions Trading Scheme pose an opportunity for the scheme to influence, and be the nucleus of, future global carbon markets.

The establishment of common incentives across different sectors is important for efficiency. The overall structure of incentives, however, will reflect other market failures and complexities within the sectors concerned, as well as the climate change externality.

The characteristics of different sectors will influence the design and choice of policy tool. Transaction costs of a trading scheme, for instance, will tend to be higher in sectors where there are many emission sources. The existing framework of national policies in these sectors will be an important influence on policy choice.

15.1 Introduction

This chapter considers how markets for emission reductions can be built on the principles considered in Chapter 14. The application of these principles requires careful analysis of the context of specific economies and institutional structures– at the national, international, regional or sectoral levels.

Section 15.2 discusses the importance of designing policies in a way which creates confidence in the future existence of a robust carbon price, so that businesses and individuals can plan their investment decisions accordingly. The current use of emissions trading schemes is discussed in Section 15.3, and 15.4 focuses particularly on the issues around creating a credible carbon price in emissions trading schemes.

The choice and design of such policy instruments also depends on the specific sectoral context. Policies which work for one sector may be inappropriate for another, although a common price is still needed across sectors for efficiency in the costs of mitigation. The relationship between climate change policy and other objectives, such as energy security and local air pollution, is also important. These issues are discussed in 15.5.

Carbon pricing is only one part of a strategy to tackle climate change. It must be complemented by measures to support the development of technologies, and to remove the barriers to behavioural change, particularly around take-up of energy efficiency. These two elements are discussed in Chapters 16 and 17.

15.2 Carbon pricing and investment decisions

Investors need a predictable carbon policy

Businesses always have to take uncertainties into account when making investment decisions. Factors such as the future oil price, changes in consumer demand, and even the weather can affect the future profitability of an investment. Business decision-makers make judgements on how these factors are likely to evolve over time.

But unlike many other uncertainties that firms face, climate change policy is created solely by governments. To be successful, a carbon pricing policy must therefore be based on a framework that enables investors to have confidence that carbon policy will be maintained over sequential periods into the future.

Serious doubt over the future viability of a policy, or its stringency, risks imposing costs without having a significant impact on behaviour, so increasing the cost of mitigation. Creating an expectation that a policy is very likely to be sustained over a long period is critical to its effectiveness.

Credibility, flexibility and predictability are key to effective policy

Three essential elements for an effective policy framework are credibility (belief that the policy will endure, and be enforced); flexibility (the ability to change the policy in response to new information and changing circumstances); and predictability (setting out the circumstances and procedures under which the policy will change). These apply to any type of policy, including the technology and regulatory measures set out in the following chapters, but are particularly pertinent to carbon pricing.

A key issue for credibility is whether the policy commands support from a range of interest groups. Public opinion is particularly important: sustained pressure from the public for action on climate change gives politicians the confidence to take measures which they might otherwise deem too risky or unpopular. It must also make sense within an international context: if there are good prospects for a robust international framework, this will greatly enhance the credibility of national goals for emissions reductions.

As Chapter 14 has discussed, the flexibility to adjust policy in the short term is an important principle for efficient pricing under conditions of uncertainty. Policy must be robust to changing circumstances and changing knowledge. If policy is seen to be excessively rigid, its credibility may suffer, as people perceive a risk that it will be dropped altogether if circumstances change.

Building in predictable and transparent revision rules from the start is the best way to maintain confidence in the policy, whilst also allowing flexibility in its application.

Issues of credibility are particularly important for investments in long-lived capital stock

Taking a long-term view on the carbon price is particularly important for businesses investing in long-lived assets[1]. Assets such as power stations, industrial plant and buildings last for many decades, and businesses making investment decisions on these assets often have longer time horizons than many governments.

If businesses believe that carbon prices will rise in the long run to match the damage costs of emissions over time, this should lead them to invest in low-carbon rather than high-carbon assets. But in the transitional period, where the credibility of carbon pricing is being

[1] See Helm et al (2005) which argues that credibility problems in recent UK energy and carbon policy have costs for meeting objectives on energy and climate change. The irreversibility of energy investments and the risk of governments reneging on commitments to carbon commitments imply a need for a more consistent policy framework.

established worldwide, there is a risk that future carbon prices are not properly factored into business decision-making, and investments may be made in long-lived, high-carbon assets.

This could lock economies into a high-carbon trajectory, making future mitigation efforts more expensive. Governments should take careful account of this: as well as providing as much clarity as possible about future carbon pricing policies, they should also consider whether any additional measures may be justified to reduce the risks[2].

Uncertainty about the long-term future framework for carbon pricing is also a reason why additional measures to encourage the development of low-carbon technologies are important. This is discussed in Chapter 16.

Policy uncertainty not only undermines climate change policy – it can also undermine security of supply, by creating an incentive to delay investment decisions.

Uncertainty about the future existence or overall direction of policy creates difficulties for how businesses respond. There is a risk that businesses will adopt a 'wait and see' attitude, delaying their investment decisions until the policy direction becomes clearer.

Blyth and Yang (2006) look at the incentives for a company faced with a decision on whether to invest in high-carbon or low-carbon infrastructure. If a decision is expected at some point in the future about whether or not a new climate change policy will be introduced, a company which makes its investment decision now, risks a loss later if it makes the wrong call on policy. If it waits until the policy is agreed, it can make a more informed choice. Given this uncertainty, a much higher expected profit level would be required to trigger the investment now[3].

In the energy sector, such delays in investment could create serious problems for a country's security of supply. Modelling work by Blyth and Yang (2006) indicates that an increase in the period of relative carbon price stability from 5 to 10 years (which could equate to increasing the length of an allocation period in a trading scheme) could reduce the size of the investment thresholds arising from uncertainty by a factor of 2 or more[4].

Credibility may also vary between policy instruments

Credibility may vary between different types of policy instrument. For instance, taxation provides governments with a revenue stream, and there tends to be an expectation that it will not be in a government's interests to abolish it. Regulation may be more effective in countries with a culture of using command and control methods, or where there are political or administrative problems with raising taxes or with tax collection. Specific national circumstances, including constitutional structures, the stability of political institutions and the quality of legal infrastructures and enforcement, play a key role in determining what credible policy is.

Another important element is the level at which policy takes place. Regulation or trading schemes which are agreed at the EU level, for instance, are difficult to reverse, and hence may be seen as more credible than some national policies.

The issues surrounding credibility in trading schemes are discussed in detail in the following section.

15.3 Experience in emissions trading

As outlined in Chapter 14, emissions trading has several benefits. Emissions trading schemes can deliver least-cost emission reductions by allowing reductions to occur wherever they are cheapest. A key corollary benefit to this is that it generates automatic transfers between

[2] Grubb et al (1995), Lecocq et al (1998).
[3] See Blyth and Sullivan (2006)
[4] See Blyth and Yang (2006)

countries, while delivering the least-cost reductions. In many instances, introducing trading schemes is also an easier mechanism through which to achieve a common carbon price across countries than attempts to harmonise taxes. As such, trading schemes can be used to introduce carbon pricing, without risking carbon leakage and competitiveness implications between participating countries. Emissions trading is therefore a very powerful tool in the framework for addressing climate change at an international level.

Emissions trading is not new to environmental policy. Trading in emissions has been used to reduce sulphur dioxide and nitrous oxide emissions that cause acid rain in the US since 1995[5]. The experience of this scheme increased interest in the potential use of emissions trading to tackle climate change – particularly due to its potential cost effectiveness compared to the use of regulation. Burtaw (1996) estimated that emissions trading under the US Acid Rain Program saved 50% of the costs compared to command and control.

The use of carbon trading schemes is expanding

During the 1990s, as experience of emissions trading for air pollution grew in the US, the EU began to consider the potential of using trading to help meet its Kyoto target emission reduction obligations. The European Commission presented a 'Green Paper' in 2000 that proposed the use of emissions trading. It showed that a comprehensive trading scheme could reduce compliance costs of meeting Kyoto by a third, compared to a scenario with no trading instrument[6].

The EU has since gone on to implement a trading scheme in major energy intensive and energy generation sectors, and in so doing, established the world's largest greenhouse gas emissions market. Launched in January 2005, the EU emissions trading scheme (EU ETS) is still in its infancy. The scheme will enter a second, longer phase in 2008, with a major review on the scheme's design from 2013 to be launched in 2007. Box 15.1 describes how the EU ETS works, and discusses the experience of the scheme to date.

Box 15.1 The European Union Emissions Trading Scheme (EU ETS)

The EU ETS is the first international emissions trading scheme.It established a uniform price of carbon for greenhouse gas emissions from specific heavy industry activities in the 25 EU member states. Phase One of the scheme was launched on 1 January 2005 and runs to the end of 2007. Phase Two runs from 2008-12, and the scheme will continue with further phases beyond 2012. Participation is mandatory for emissions from industrial sectors specified in the scheme. These currently include energy generation, metal production, cement, bricks, and pulp and paper[7].

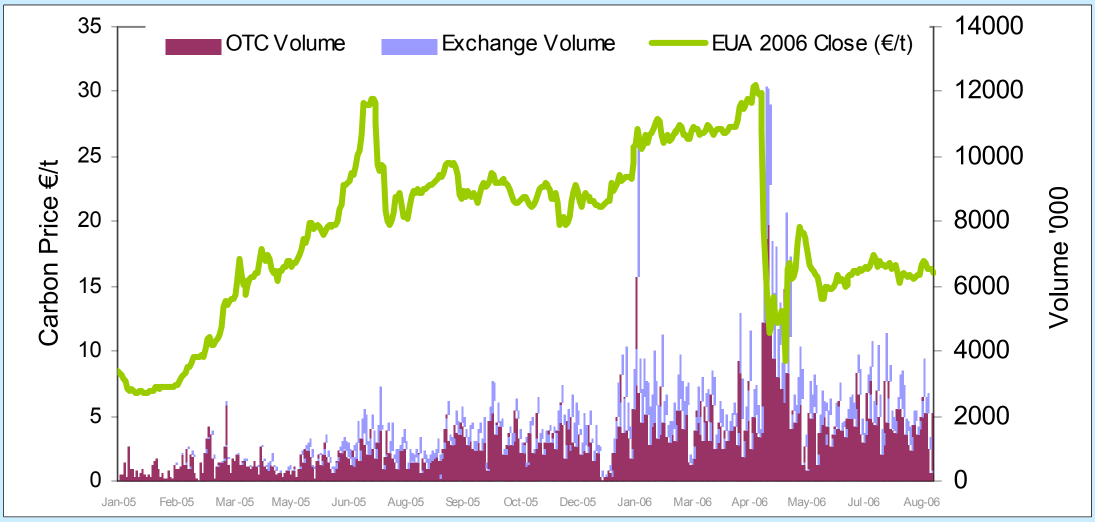
Member states decide, through their National Allocation Plans (NAPs), on the quota or total allocation of allowances for each phase within their country, and on how these are distributed between companies. The plans are subject to approval by the European Commission. They must demonstrate that allocation levels will not exceed expected emission levels in sectors, and are in line with broader plans to make reductions to meet Kyoto targets[8]. Allowances are then issued to all firms on the basis of the NAP. Firms in the scheme must provide an annual report on their emissions, which is audited by a third party.

In Phase One, the scheme covers less than 40% of all EU25 GHG emissions[9], with the permit market over the three-year period worth around US $115 billion[10]. The majority of permits are

[5] See www.epa.gov/airmarkets/arp/index.html for more detail on the US Acid Rain Program.
[6] The 2000 Green Paper estimated the cost of meeting Kyoto as €9 billion euros without trading, €7.2 billion with trading amongst energy producers only, €6.9 billion with trading among energy producers and energy intensive industry and €6 billion with trading among all sectors. See EC (2000).
[7] The scheme covers emissions from heat and energy use from installations of a particular size in these sectors. See EC (2003) for more detail on the scope of the EU ETS
[8] Articles 9 to 11 and Annex III of EU (2003) outline the criteria for allocation in the NAP
[9] Based on emission estimates for EU25 countries in WRI (2005)
[10] This assumes around 2 billion tonnes of allowances are allocated each year for three years, and that the average allowance price is $19 (€15)

currently allocated for free to installations included in the scheme (only 0.2% of all allowances will be auctioned in Phase One[11]), and most member states have prevented the banking of allowances between the two phases. An allowance market has developed through trade exchanges and brokers, with the City of London emerging as an important location for trading. Traded volumes have grown steadily (see below). The price of allowances has been in the range of €10 to €25 per tonne of CO_2 for most of the period, with a steep price drop in April 2006.

The market for EU allowances (EUAs) –prices and volumes



Source: Data taken from Point Carbon, www.pointcarbon.com

Early experience in the scheme has highlighted a number of important issues:

- **The potential for emissions trading schemes to generate demand for emissions reductions in developing countries**: the Linking Directive has enabled EU-based industry to purchase carbon reductions from the cheapest source, including projects and programmes being implemented in the developing world through the use of the Clean Development Mechanism[12]. This has driven growing interest of EU firms in the CDM market, particularly as CDM credits can be used in either phase of the scheme. The CDM market volume grew threefold between 2005 and 2006, to 374 million tonnes (CO_2e), much of this driven by demand from the EU ETS[13].

- **The importance of long term confidence in the future of the scheme:** the EU ETS will continue with a third phase beyond 2012. But companies would like greater clarity over what the EU ETS will look like in Phase III and beyond in order to help judge the impact on their investment decisions. A survey to discover the issues that need to be considered in the review of the EU ETS put the need for certainty on future design issues in the scheme as a top priority[14]. The majority of those surveyed also stated they would prefer allocation decisions to be made a few years in advance of trading periods, and trading periods be lengthened to around 10 years.

[11] Schleich and Betz (2005)
[12] The Clean Development Mechanism is one of the flexible mechanisms under the Kyoto Protocol. Its operation is discussed in detail in Chapter 23.
[13] Capoor and Ambrosi (2006) state that European and Japanese private entities dominated the buy-side of the CDM market in 2005 and 2006, taking up almost 90% of transacted project emissions credits.
[14] See McKinsey et al (2005) for details of the survey of governments, companies and NGO views on issues for the Review of the EU ETS. For UK companies, see also UKBCSE and The Climate Group (2006)
[15] Grubb et al (2006)
[16] Grubb et al (2006)
[17] EC (2005)
[18] See Kruger and Egenhofer (2005). Also, some countries such as the UK went further asking firms to provide verification of data submitted by firms on historic emissions which werebaselines for initial allocations.
[19] See EC (2004) for details of these guidelines.
[20] See Egenhofer and Fujiwara (2005)

- **The impact of imperfect information on prices:** at the start of trading in January 2005, traders had limited information on supply and demand for emission allowances. In particular, the NAPs did not contain clear data on the assumptions lying behind the projections of emissions used as the basis for allocations. The release of the first data on actual emissions from the scheme's participants in April 2006 led to a sharp downward correction in prices (see figure above), as the data showed that the initial NAP allocations exceeded emissions in most sectors of the scheme[15]. The volatility that this caused demonstrates the importance of transparency in initial allocation plans.

- **The difficulties of ensuring scarcity in the market:** overall allocation in the EU ETS market is not set centrally. Rather, it is the sum of 25 individual member state decisions, subject to approval by the Commission. As such, total EU allocation is an outcome of many decisions at various levels, with a risk of gaming on allocation levels between member states if they make their decisions expecting allocation levels will be higher elsewhere in Europe. It has therefore been difficult to ensure scarcity in the EU ETS market. As a result, the total EU wide allocation in Phase One is estimated to be only 1% below projected "business as usual" emissions[16],[17]. This underlines the need for stringent criteria on allocation levels for member states, and robust decisions by the European Commission on NAPs to ensure scarcity in the scheme.

- **The need for robust administrative systems:** the methods used to determine allocations placed considerable demands on companies to collect, verify and submit historical data on emissions.In addition, to ensure confidence in compliance standards across the EU on measuring emissions[18], companies had to set up monitoring, reporting and verification systems in line with EU guidelines[19]. Costs were high for small firms that had low annual emissions included in the EU ETS; requests to reconsider the minimum size of plants included in the scheme have subsequently been made by both member states and business.[20]

The growing importance of the use of emissions trading markets to price carbon is also illustrated by the scope of trading schemes planned or already operating across the world. Norway introduced emissions trading in January 2005 for major energy plants and heavy industry. New South Wales (Australia) already operates a mandatory baseline-and-credit scheme for electricity retailers. Japan and South Korea are also running pilot programmes for a limited number of companies.

Elsewhere, the biggest plans for new emissions trading markets are in the USA, through the Regional Greenhouse Gas Initiative (RGGI) from January 2009[21], and California's plans for using a cap and trade scheme from 2008[22]. Switzerland and Canada also plan to implement trading schemes as part of their programmes to meet Kyoto commitments.The voluntary market for carbon reductions is also growing, driven by demand from both companies and individuals looking to reduce or offset their emissions[23]. The CCX (Chicago Climate Exchange) is an example of a voluntary carbon market. Since December 2003, US based companies that take on voluntary targets to reduce GHG emissions have used this market to achieve their targets.

The following section outlines the design issues that impact on trading scheme efficiency and market effectiveness.

[21] RGGI covers Connecticut, Delaware, Maine, New Hampshire, New Jersey, New York and Vermont. See www.rggi.org for more details.
[22] See announcements by the Governor of the State of Calitornia, www.climatechange.ca.gov
[23] See Butzengeiger (2005) and Taiyab (2006) for more on markets for voluntary carbon offsets

15.4 Designing efficient and well-functioning emissions trading schemes

To reap the benefits of emissions trading, deep and liquid markets and well-designed rules are important.

Emissions trading schemes will, necessarily, deliver carbon prices that vary over time. But a degree of price stability through the emergence of a predictable average price within the emissions trading mechanism is important, particularly for businesses planning long-term investments. And the efficient operation of the scheme, including its impact on incentives, is important to achieve least-cost reductions.

One option to limit the bounds of price movements is to supplement the market instrument itself with price controls, such as formal price caps and price floors[24]. Although this approach has some attractions in principle, there are significant problems with its practical implementation and effectiveness, including the implications for the feasibility of linking with other schemes. These are set out in Box 15.2.

Box 15.2 Price caps and floors in emission trading schemes

As explained in Hepburn et al (2006), a hybrid instrument can in principle be tailored to ensure that in the long term, an overall quantity ceiling is achieved, but that in the short term there is sufficient flexibility to avoid temporarily very high marginal abatement costs. This would help to achieve the balance of long-term certainty and short-term flexibility discussed in Chapter 14.

Price caps (or 'safety valves')[25] supply allowances on demand if the agreed ceiling price is hit, and would eliminate the risk of price spikes. Price floors would stop the carbon price from falling below a minimum level. They can be implemented in a number of ways, including through a levy that only becomes operational once the floor is breached, or by guaranteeing a minimum future quota price to emitters, by entering a contract to buy permits (which the government can then sell back to the market)[26] – although the risks to the public finances from this latter route should be taken seriously.

However, people would still have to believe that the caps and floors themselves will not be changed. There are also risks that the imposition of a cap alone would damage incentives for investing in low carbon technologies as it sets an upper limit on the future expected price, lowering potential returns to low carbon technology[27].

Importantly, the use of different price caps and floors in different schemes would compromise the efficiency of regional trading schemes- there are risks of carbon leakage and unintended transfers across jusrisdictions with different carbon price ranges. As such, to operate efficiently, price caps and floors would need to be the same across all participating countries. Agreeing a common price cap or floor across countries is likely to suffer from the same difficulties as any attempt to harmonise carbon taxes more generally. Even if countries within a single scheme could agree a cap or floor, this would present an obstacle to linking to other schemes with different rules. This is a drawback to the practical applicability of these methods.

Fundamentally, to ensure confidence in a stable long-term carbon price, and to realise the full efficiency benefits of any trading scheme, the creation of deep, liquid and efficient markets is essential. Several factors can facilitate this:

[24] See, for instance, Pizer (2002) and Pizer (2005)
[25] See Jacoby and Ellerman (2004)
[26] Helm and Hepburn (2005)
[27] Blyth and Yang (2006) modelling shows that in principle, price caps and floors would reduce uncertainty on future prices, but as people need to believe that caps will stay the impact is limited.Stronger effects on reducing uncertainty come from lengthening the period of price stability from 5 to 10 years as discussed above.

- **Broadening the scope** of the scheme, to include more gases, more countries, and international credits;
- Ensuring appropriate **scarcity** in the system;
- **Lengthening the trading periods**, to provide longer-term confidence;
- Designing appropriate **allocation schemes**; and
- Promoting **transparency**.

The following sections discuss these in more detail.

Broadening the scope of the scheme will tend to lower costs and reduce volatility

In general, the deeper and more liquid a market, the harder it is for any individual trade to affect the overall price level, and hence the less volatile the market will tend to be. Introducing different economic sectors or countries to a market can also reduce the impact of a shock in any one sector on the scheme as a whole. In addition, the greater the degree of flexibility about what type of emissions reductions are made and where they are made, the lower the cost will be.

There are a number of ways to widen the scope of trading schemes. One is to widen the number of sectors and activities covered by an individual scheme. Some of the practical issues associated with this are discussed in Section 15.5 below.

Another is to offer access to flexible mechanisms such as Joint Implementation (JI) or the Clean Development Mechanism (CDM)[28]. This expands the options for generating credits for emissions reductions to most parts of the world, maximising the opportunities for efficiency. The environmental benefits of using these credits will depend on the credits representing a real reduction on what emission levels would otherwise have been (the 'business as usual' level of emissions). Countries that can generate CDM credits do not have binding caps on emissions, and are often fast changing economies; as such, establishing a credible estimate of what a business as usual baseline is, and whether reductions would have taken place in the absence of the CDM project, can be complex[29]. Chapter 23 examines this in more detail.

Linking different national or regional cap and trade schemes is also desirable on efficiency grounds, but, to reap the efficiency benefits, the schemes should be broadly similar in design. The practical issues of linking are discussed in Chapter 22.

The introduction of new sectors, and linking to new regions, can cause some short-term price instability, as there is uncertainty over the net impacts of newly included sectors and their response to the scheme. But the impact on long-term stability should still be positive.

As well as bringing extra depth and liquidity into markets, commonality or linking of schemes avoids the leakage, confusion and inefficiency of parallel schemes with different carbon prices. In any one area or country, a single or unified scheme is better than a proliferation of schemes.

The degree of scarcity in the market is important in determining prices

To facilitate more stable carbon markets, allocation levels should be consistent with overall national, regional or multilateral emissions reductions targets, and be clearly below expected 'business as usual' (BAU) emissions. This is complicated by the uncertainties in predicting future emissions over an entire trading period.

The first phase of the EU ETS illustrates this. Allocation decisions were based on projections of BAU emissions of the sectors in the scheme, many of which appear to have been overestimated, meaning that total EU allocation was just 1% under projections of BAU of the

[28] These mechanisms are discussed fully in Chapter 23.
[29] The CDM Executive Board approves methodologies for baseline setting in CDM projects. See Chapter 23.

whole EU ETS. In contrast, earlier emissions trading schemes such as the US Sulphur Dioxide trading programme, had allocation levels at around 50% below baseline emissions[30].

The degree of scarcity in a scheme depends not just on the cap which is set for the scheme itself, but also on whether or not companies are permitted to use credits for emission reductions that are generated in areas without a cap, such as those from the CDM. As long as these credits represent real emission reductions, there is little reason to limit their use, as cost-efficiency demands that emissions reductions are made wherever this is cheapest.

If allowing the use of mechanisms such as the CDM turns out to deliver large quantities of low-cost reductions into a trading scheme, then, at the time when allocations for subsequent periods for the scheme are set, the cap may need to be tightened to ensure that the carbon price continues to reflect the social cost of carbon, and is consistent with the achievement of the long-term goal for stabilisation. The impact of CDM credits on the price should be considered alongside other emerging information on the costs and benefits, as part of the revision process for allocations.

Greater certainty on the evolution of prices over future trading periods, and banking and borrowing between periods, can help to smooth compliance over time and investment cycles

Longer trading periods in trading schemes can help to smooth compliance over time and investment cycles, as they allow the private sector to have greater control over the timing of the response to carbon policy. They also reduce policy risk to the extent that they suggest a deeper commitment to carbon policy. However, excessively long commitment periods limit policymakers' flexibility in responding to changing information and circumstances.As the previous chapter discussed, this is important in order to keep down the overall costs of carbon pricing to the economy[31], and to readjust targets as more information on climate change itself is gathered.

The key issues for investor confidence are a commitment to the long-term future of the scheme and predictability in its overall shape and rules. This predictabilty can be achieved through establishing revision rules for future allocation periods. For instance, governments may announce that future allocations will be contingent on factors such as the price of permits in the preceding period. They could also announce a target range for prices[32] (which should be in line with the expected trajectory for the social cost of carbon – see Chapter 13). Setting out expectations on issues such as expansion to new sectors, or the use of CDM, could also be important. These principles could be set over a very long time period of perhaps 10 to 20 years, with allocations made at more regular intervals.

Within this framework, banking, and possibly borrowing, can be used to create links between different phases of a trading scheme. Banking is the ability to carry over unused quotas from one period to another, and borrowing the ability to use or purchase quotas from a future period in the current period. This allows trading to take place across commitment periods, as well as across sectors and countries. This can improve flexibility, as well as reducing the risk of price spikes or crashes at the end of trading periods discussed above.

Some existing emission trading schemes already allow banking. Banking should help to encourage early emission reductions where this is more cost effective[33]. For example, the heavy use of banking in the US Acid Rain Program has been seen by some as a success in terms of delivering early reductions and improving efficiency. Ellerman and Pontero (2005) found that 30% of allowances were banked between 1995-99 (Phase One of the programme). Firms made efficient decisions to make earlier reductions and bank allowances forward, due to the expectation of tighter caps in future phases. As a result, in total, emissions reduced in Phase One were twice that required to the meet the cap.

[30] See Grubb and Neuhoff (2006) for a discussion of the use of projections and price volatility in the EU ETS.
[31] Helm and Hepburn (2006)
[32] See Newell et al (2005) for an example of how such revision rules could work.
[33] However, unrestricted banking can also allow emissions to be concentrated in time (Tietenberg,1998) – and such hoards of emissions could have high associated damage costs compared to dispersed emissions.

In contrast, very few existing emissions trading schemes have made use of borrowing. The main reason why borrowing has been restricted in existing trading schemes is credibility and compliance, including the risk of borrowing simply being offset by compensating increases in allocations in future periods. In theory, unrestricted borrowing could delay emissions reductions indefinitely, thus raising the risk of 'overshooting' a long run quantity ceiling. A credible enforcement strategy, and long-term principles for allocation, are therefore essential to ensure that reductions borrowed from the future are real and delivered.

Where there are longer periods within which compliance is possible, and a clearer view of the longer term direction of carbon policies, liquid futures markets in carbon are more likely to emerge, and hedging instruments will be developed that allow firms to manage price uncertainty more systematically.

The choice and design of allocation methodology is an important determinant of both efficiency and distributional impact

Permits in an emissions trading scheme can be allocated for free, or sold (usually, though not necessarily, through auction[34]). It is possible to combine these – for instance, the EU ETS allowed for up to 5% of permits to be auctioned in Phase One, and 10% in Phase Two.

In principle and assuming perfect competition, free allocation and auctioning should both be equally efficient. In both cases, businesses face the same marginal costs arising from the emission of an extra tonne of carbon dioxide, and should therefore make the same decision on whether or not to emit in either case.

But this argument is static, ignores the structure of markets and takes no account of distributional or public finance issues. In reality the methods differ in two important respects. First, free allocation methodologies can dampen incentives to incorporate the cost of carbon into decision making consistently, and distort competition. Thus they slow adjustment and potentially raise the overall cost of compliance.

Second, they differ in their distributional impact. Free allocations give companies lump sum transfers in the form of carbon allowances; depending on market structure and demand.Such transfers may result in windfall profits. Not surprisingly, free permits are generally favoured by existing players in an industry. Auctioning leads to financial transfers to governments, which may have benefits for the public finances, depending on whether this is a new revenue flow or a substitute for other sources of finance.

These issues were raised in the preceding chapter, and are explored in the next two sections.

Free allocations can significantly distort incentives

There are a number of reasons why emissions trading schemes based on free allocation may distort incentives for emissions reductions:

- If there is an expectation that the baseline year upon which free allocations are based will be updated, participants have incentives to invest in dirty infrastructure and emit more now to get more free allowances in the future[35]. A one-off allocation based on past emissions (or grandfathering) over all trading periods is one way of avoiding this. However, as a trading scheme matures, the relevance of past emission levels may become a less and less relevant basis for the likely emissions of each plant, say ten or more years later.

[34] The discussion in this section assumes that the sale of permits to industry would happen through auctioning. Other methods are also possible, such as direct sales; these are not discussed fully here, but would be subject to some of the same arguments.
[35] Neuhoff et al (2006) also find that in an international emissions trading scheme, if updating is used in one country but not others, it equates to free riding by the country that uses updating.

- Free allocations can act as a disincentive to new entry to a market, restricting competition and reducing efficiency. If incumbents receive free allowances, but new plants must purchase allowances, free allocations directly create barriers to entry, meaning that the provision of free allocations for new plants may be required[36]. In turn, the rules for free allocations to new plants may indirectly distort incentives: if allocations are given in proportion to the expected emissions from the new plant, they may reward higher-carbon technologies[37].

- There may also be disincentives to exit from markets. The existence of 'use it or lose it' closure rules, which mean a plant must be open in order to receive free allowances, may prevent the closure of inefficient plants.This would mean emission levels are higher than if plants could keep allowances if they shut down, or had no free allowances to begin with[38].

- Under auctioning, with no lump sum of free allowances, businesses will face upfront costs in buying permits to cover their emissions. This will tend to bring management attention to the importance of making efficient decisions that fully account for the cost of carbon. Free allocations may not have the same behavioural impact, delaying adjustments to making effective decisions on carbon compliance[39].

Free allocation methodologies can therefore seriously reduce the dynamic efficiency of a trading scheme, making the cost of reductions higher in the longer term than would otherwise be the case.

Benchmarking the emissions needed for efficient low carbon technologies for both existing and new plants is an alternative basis for issuing free allocations. It offers the opportunity to more clearly 'reward' clean technologies, and penalise carbon intensive technology by developing an average 'rate' of emissions for particular fuels, technologies or plant sizes. The more standardised a benchmark is, the more effective benchmarking is likely to be[40]. Benchmarking can also be used specifically for new entrants, by allocating on the basis of the most efficient technologies available[41].

Auctioning can avoid many of the incentive problems associated with free allocation, although good design is necessary to avoid introducing new inefficiencies. Small, frequent auctions may be more effective in limiting any market power that may exist in the permit market[42]. In principle, to ensure an efficient outcome, the auction method should promote competition and participation for small as well as larger emitters. While one auction at the beginning of the permit period may minimise administration costs, it may also carry a risk of larger players buying the majority of permits and extracting oligopoly rents in the secondary permit market. More frequent auctions also allow for all players to adjust bids and learn from experience of early auctions, and may be helpful in promoting price stability[43]. Given the administrative costs of the data required for free allocation methodologies, auctioning may also offer lower administrative costs to both firms and governments.

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[36] In an international trading scheme, if one country has free allowances for new plants, there are compeitiveness implications if other countries do not. This logic drove all 25 EU member states chose to set aside of allowances for new entrant plants that total around 5% of all EU allowances.

[37] Modelling of the UK electricity sector in Neuhoff et al (2006), demonstrates that free allowances for new plants using high carbon technologies could increase overall emissions. The existence of a 'use it or lose it ' closure rule for EU ETS allocations will reduce plant retirement rates and reduce investment in new plants, causing higher emission levels.

[38] In the EU ETS, most member states had 'use it or lose it' closure rules, mainly due to the rules for free allocation to new plants. In Germany, a 'transfer rule' allowed allowances from old plants to be retained if a new plant was built. This still risks new plants receiving higher allocation levels than needed.

[39] Hepburn et al (2006a)

[40] Neuhoff et al (2006) show that for generation plants in the EU ETS, benchmarks based on plant capcity as opposed to fuel and technology specific benchmarks are the least distorting.

[41] The use of benchmarking on the basis of low carbon technology emission rates is an option and has been used in the EU ETS NAPs of some member states. See DTI (2005) for an example of the use of benchmarks for 'new entrant' plants in the UK

[42] Hepburn et al (2006a) considers auction design in the EU ETS

[43] Hepburn et al (2006a)

Using free allocation has benefits for managing the transition to emissions trading, but risks creating substantial windfall profits

Free allocations and auctioning have very different distributional impacts. This has led to a debate over whether allocation methods will affect the profitability of firms, as well as the implications for competitiveness. Carbon pricing will most affect the operating costs of energy intensive industries that compete in international markets, such as non-ferrous metals and some chemicals sectors (see Chapter 11). In the first instance, as auctioning and free allocation both impose the same marginal cost on emissions (as the carbon price is the same), the profit maximising quantity and price for any company should be the same in each case, and there should be no impact on the fundamental risks to competitiveness from the choice of allocation method.

There is, however, an important difference in terms of the impact on companies' balance sheet, which may have competitiveness implications[44]. A firm with free allocations that competes against other firms who face the cost of carbon but do not have free allowances, would be in an advantageous direct position in the sense that it receives a subsidy. It could for example, use this to capture market share by a period of low prices. However, if a firm competes against other firms who do not face a cost of carbon, the 'subsidy' of free allowances may be used to maintain its competitiveness, rather than gain competitive advantage over other firms.

This subsidy effect means that free allocations may have an important role to play in managing the transition to carbon pricing. Full auctioning imposes an immediate hit on companies' balance sheets equivalent to the full cost of all their emissions, whereas free allocation means that companies only have to pay for the cost of any additional permits they need to purchase. This difference in upfront costs may be important, particularly for firms that have significant sunk costs in existing assets and need to invest in lower-carbon assets in response.

In terms of the impact on firms' profits, free or purchased allowances are one factor influencing whether firms face profit or losses from the introduction of a trading scheme. Emissions trading increases the marginal costs of production, but the extent to which firms have to internalise these costs and therefore suffer reduced profits, will depend on:

- whether they can pass on costs to consumers (which depends on market structure and the shape of the demand curve for the good);
- whether they have ways of reducing emissions themselves which are cheaper than buying allowances (cost effective abatement); and
- whether they have some free allowances that can compensate for increased marginal costs

A firm that receives free allowances equal to its existing emissions can make the same profits as before from unchanged production activities, provided the market price for its output is unchanged – or do still better by responding to the new price for carbon. What happens to the market price for its product will depend on industrial structure.

If firms are in perfectly competitive markets, the increase in marginal costs from emissions trading will be fully reflected in prices to consumers, and (in the absence of abatement) profits will stay the same as before the scheme's introduction. Any free allowances they receive equate to windfall profits[45]. But where firms operate in markets where there is international competition and/or very elastic demand and so are unable to pass on costs, free allowances

[44] Smale et al (2006) show that marginal cost increases from the EU ETS most affects the competitiveness of the aluminium sector as it competes in a very global market, and does not get free allowances to compensate-the aluminium sector is currently not directly covered by the scheme, but still faces higher electricity prices.
[45] Sijm et al (2006) show that in the EU ETS, free allocation to electricity generation companies has created substantial windfall profits while consumers have faced increased electricity prices to reflect allowance costs.

can act to maintain profitability by compensating for the increasing operating costs and reduced revenue that may be necessary to maintain market share[46].

Nevertheless, whatever the market structure, it is important that free allocations are only temporary. They may be necessary to manage a transition, but if permanently used, they would distort competition and emission reductions will be below their efficient levels.

The creation of robust institutions, and the collection and provision of reliable information, are important for efficiency

Price stability can also be encouraged by the provision of robust information. In particular, transparent and regular information on actual emissions of scheme participants, as well as on the intial allocations, will help to reveal the basis of market demand and supply.

The importance of information of this kind is illustrated by the experience of the EU ETS when the first verified emissions data of installations included in the scheme were published in March 2006. As Box 15.2 showed, prices dropped sharply in response, as it was clear that, for many firms, actual emissions were well below the number of allowances given to them at the start of the scheme. Revealing information on actual emissions more regularly through the trading period would help limit this volatility. Such requirements for more frequent information releases would, however, impose additional costs on emitters, implying that these requests may need to be limited to the largest emitters.

The quality of monitoring, reporting and verification standards is integral to confidence in a trading scheme. A transparent and well enforced system of measuring and reporting emissions is crucial for securing the environmental credibility of a scheme as well as free trade across plants. Monitoring, reporting and verification (MRV) rules ensure that a tonne of carbon emitted or reduced in one plant is equal to a tonne of carbon emitted or reduced in a different plant[47].

Just as these issues are important in national and regional emissions trading schemes, the emergence of a liquid and efficient global carbon market has similar requirements. Indeed, to facilitate such a market, the EU and others wanting to develop global emissions trading will need to build on existing institutions to develop trading infrastructure. The World Bank emphasises that this includes ensuring strong legal bases to enforce compliance in the jurisdictions of participating firms and agreeing on minimum standards for monitoring, reporting and verification of emissions. Institutions that can deliver predictable and transparent information for emissions markets will also be vital, as will general oversight on the transparency of financial services that support trading such as securities, derivative products or hedge funds[48].

Drawing out implications for the future of the EU emissions trading scheme

The EU ETS will continue beyond 2012 with a third phase. The details of Phase III have yet to be determined, and will be considered in the European Commission's review of the EU ETS in 2007. The review will propose developments in the scheme, drawing on the experience of the EU ETS to date. In particular, it will consider the expansion of the scheme to other sectors (including transport) and links to other trading schemes.

Decisions made now on the third phase of the scheme that will run post 2012, pose an opportunity for the EU ETS – the most important emissions trading market – to influence other emerging markets, as well as to be the nucleus of future global carbon markets. Based on the analysis in this section, there are certain key principles to consider in taking the EU ETS scheme forward. These are set out in Box 15.3.

[46] To maintain profits, commentators state various levels of free allocation as necessary, they need not be 100%. See, for instance, work by Bovenberg and Goulder (2001), Smale et al (2006), Vollebergh et al (1997), Quirion (2003) on allocation and profitability. Also Hepburn et al (2006b) provide a generalised theoretical framework, including an analysis of asymmetric market structure and apply this to four EU ETS sectors.
[47] Kruger and Egenhofer (2005)
[48] Capoor and Ambrosi (2006)

Box 15.3 Principles for the future design of the EU ETS

A credible signal

- Setting out a **credible long-term vision** for the overall scheme over the next few decades could boost investor's confidence that carbon pricing will exist in the EU going forward
- The overall EU limit on emissions should be set at a level that **ensures scarcity** in the allowance market. Stringent criteria for allocation volumes across all EU sectors are necessary.
- To realise efficiency in the scheme, and minimise perverse incentives, there should be a move to **greater use of auctioning** in the longer term, although some free allocation may be important to manage short-term transitional issues[49].
- Where free allocation is necessary, standardised **benchmarking** is a better alternative to grandfathering and updating.

A deep and liquid market

- **Clear and frequent information on emissions** during the trading period would improve the efficient operation of the market, reducing the risks of unnecessary price spikes.
- Clear and predictable **revision rules** for future trading periods, with the possibility of **banking** between periods, would help smooth prices over time, and improve credibility
- **Broadening participation** to other major industrial sectors, and to sectors such as aviation, would help deepen the market[50].
- Enabling the EU ETS to **link with other emerging trading schemes** (including in the USA and Japan) could improve liquidity as well as establish the ETS scheme as the nucleus of a global carbon market.
- **Allowing use of emission reductions from the developing world** (such as the CDM or its successor) can continue to benefit both the efficiency of the EU scheme as well as the transfer of low carbon technology to the developing world

15.5 Carbon pricing across sectors of the economy

Abatement costs are minimised when the carbon price is equalised across sectors

As discussed in Chapter 9, sectors vary widely in terms of the current availability and average cost of abatement options. The cost of avoiding deforestation, for instance, appears to be relatively low compared with the cost of many low-carbon power generation options; by contrast, in aviation, although there are some opportunities for efficiency gains, options for technology switching are currently very limited.

As discussed in the previous chapter, to minimise the total cost of abatement, the carbon price (whether explicit via a tax or trading instrument, or implicit via regulation) should be equalised across sectors. When the carbon price is applied to sectors with cheap abatement options, initially, emissions will tend to decline more; when applied to sectors with more expensive abatement options, the degree of abatement will be less than in cheaper abatement sectors. At the same time, the price increase for the output of the latter sectors will be, and should be, greater.

This means that from an efficiency perspective, sectors with expensive abatement options should not be excluded from carbon pricing; but neither should they be subject to a different higher carbon price in that sector in order to achieve abatement.

[49] See Neuhoff et al (2006) for more on free allocation and perverse incentives in the EU ETS
[50] See Environment Agency (2006) for more detail on expansion options in the EU ETS.

As well as carbon pricing, governments should also look at the use of technology policies and efficiency policies across sectors – these are considered in the following two chapters. It is also important to consider climate change policy within the context of meeting other policy objectives within sectors, including its interaction with the treatment of externalities such as local air pollution and congestion.

The overall structure and scale of policy incentives will therefore reflect other market failures and complexities within the sectors concerned, as well as the climate change externality. As economies make the transition to full carbon pricing, they may in practice use a mix of instruments.

How the characteristics of different sectors affect choice and design of instrument

The characteristics of sectors may influence the choice and design of the carbon pricing instrument. The underlying economic structures in which the emitters operate in sectors will differ, with implications for the attractiveness of using tax, trade or regulation instruments.

Some of the relevant features of different sectors include:

- Transaction costs: this may be affected by the number and dispersion of emitters, and the institutional arrangements for monitoring and pricing.
- Carbon leakage: this is the risk that emissions-intensive activity moves to an area not subject to a carbon constraint. The choice and design of an instrument may have implications for carbon leakage and competitiveness.
- Distributional impacts: depending on the market structure of the sector, the choice of policy instrument may have different implications for who bears the cost.
- Existing frameworks: policy choices will be influenced by existing national policy frameworks and regulatory structures.

It is also important to consider where in the value chain to price carbon. If “upstream” emissions are priced (for instance, at the power station or oil refinery), it is not necessary to price “downstream” emissions as well (for instance, in domestic buildings or individual vehicles). However, Chapter 17 focuses particularly on policies to enable investments in energy efficiency by the end-user, which are not discussed separately here.

The following sections analyse how these factors influence policy choice in power and heavy industry, road transport and aviation, and agriculture.

Power and heavy industry

At a global level, power and heavy industry (such as iron and steel, cement, aluminium, paper industries and chemical and petrochemicals) are large emitters. Because of their high carbon intensity, these sectors are likely to be very sensitive to carbon pricing. They typically invest in very long-lived capital infrastructure such as power plant or heavy machinery, so a clear indication of the future direction of carbon pricing policy is particularly important to them.

Power markets in particular are characterised by imperfect market structures, including state monopolies, regulatory constraints, and often large-scale subsidies. The interaction of carbon pricing with these imperfections is complex. Other industries such as paper and chemicals are more decentralised and deregulated. But overall, sources of emissions are concentrated amongst a relatively few, large, stationary installations, where emissions can be effectively measured and monitored.

The concentrated nature of emissions from these sources make them, in principle, well suited to emissions trading. As already discussed, the first and second phases of the EU ETS cover emissions from these sectors. Other trading schemes have a similar focus – the Regional Greenhouse Gas Initiative in the north-east of the USA, for instance, will cover only the power sector.

However, trading is not the only option. Tax could also be an effective mechanism, and would have the advantage of providing greater price predictability. Examples of countries using taxation to meet climate change goals in these sectors include the UK, which has used the Climate Change Levy, a revenue-neutral mechanism which encourages emissions reductions across sectors including industry; and Norway, which introduced a carbon tax in the early 1990s, covering much of its heavy industry as well as the transport sector (Box 15.4).

Box 15.4 A carbon tax in practice: Norway[51]

Like other Scandinavian countries, Norway introduced a carbon tax in the early 1990s. The tax was to form part of substantial shift in fiscal policy as Norway aimed to use the revenue generated by environmental taxes to help reduce distorting labour taxes.

The Norwegian carbon tax initially covered 60 percent of all Norwegian energy related CO_2 emissions. There are several sectors that were exempted from the tax, including cement, foreign shipping, and fisheries. Natural gas and electricity production are also exempt, although virtually all Norway's electricity production is from carbon-free hydroelectric power. Partial exemptions apply to sectors including domestic aviation and shipping, and pulp and paper.

The tax generates substantial revenues; in 1993 the tax represented 0.7 percent of total revenue, which by 2001 had increased to 1.7 percent. The tax is estimated to have reduced CO_2 emissions by approximately 2.3% between 1990 and 1999[52]. Overall in Norway, between 1990-1999 GDP grew by approximately 23 percent, yet emissions only grew by roughly 4 percent over the same period, indicating a decoupling of emissions growth from economic growth.

There is also some evidence that the tax helped to provide incentives for technological innovation. The Sleipner gas field is one of the largest gas producers in the Norwegian sector of the North Sea. The gas it produces contains a higher CO_2 content than is needed for the gas to burn properly. With the imposition of a carbon tax the implied annual tax bill to Statoil, the state oil company, was approximately $50m for releasing the excess CO_2. This induced Statoil researchers to investigate the storing of excess carbon dioxide in a nearby geological formation. After several years of study, a commercial plant was installed on the Sleipner platform in time for the start of production in 1996. Experience with this plant has has made an important contribution to the understanding of carbon capture and storage technology.

However, there have been some difficulties in the implementation of the tax:

- The impact of the tax on industry was weakened because of numerous exemptions put in place because of competitiveness concerns. This created a complex scheme, and blunted the incentive for industry to modify or upgrade existing plants.
- The carbon tax did not reflect the actual level of carbon emitted from fuels. For instance, low and high-emission diesel fuels are taxed at the same level, despite causing different levels of environmental damage.
- Although Norway, Sweden, Finland and Denmark all put carbon taxes in place in the early 1990s, they have not been able to harmonise their approaches – demonstrating the difficulties of co-ordinating tax policy internationally, even amongst a relatively small group of countries.

Heavy industries compete in international markets, and as Chapter 11 illustrated, there are some risks to competitiveness and of carbon leakage from the use of carbon policy in such sectors. In terms of tax and trading instruments, there may be a difference in impact if taxes cannot be harmonised globally. This is because an international trading scheme imposes a

[51] This draws on Ekins and Barker (2001)
[52] Bruvoll and Larsen (2002)

uniform carbon price across countries, minimising competitiveness implications for countries within the scheme, whereas taxes may impose different costs in different countries.

Regulatory measures have not played a major role in these sectors, although these have been used for other pollutants in the power sector, the EU's Large Combustion Plants Directive being one example. The concentrated number of companies and sources of emissions may make formal or informal sectoral agreements on best practice an effective complement to carbon pricing – this is discussed in Chapter 22.

Road transport

Although the production of fuel for road transport is centralised at oil refineries, most of the emissions from road transport come from a very large number of individual cars and other vehicles. Demand for transport tends to rise with income. There is considerable scope to improve efficiency in the sector, although the responsiveness of demand to price is low, and breakthrough technologies such as hydrogen are still some years away.

Many countries currently levy a road transport fuel tax. Fuel taxes are a close proxy for a carbon tax because fuel consumption closely reflects emissions. They are frequently aimed at other externalities at the same time (discussed further below), and have the advantage of providing a steady revenue stream to the government. Another example is taxes on purchase or annual car taxes, which can be calibrated by the efficiency of the vehicle.

However, it is also possible to use emissions trading in the road transport sector (see Box 15.5). A possible risk of including road transport in an emissions trading scheme is that permit prices and oil prices might move in tandem, thus exacerbating the extent of oil price fluctuations facing the motorist (in contrast to taxes, which are levied as a fixed amount rather than a percentage of fuel price charged, meaning that the fuel price is prone to less variation).

Box 15.5 Ways to include road transport in an emissions trading scheme

There are three main ways in which emissions from road transport could be included in an emissions trading scheme; they differ according to whom the permits are allocated to.

- Motorists. Individual motorists would have to surrender permits whenever they purchased fuel. Quantity instruments might be better than prices at encouraging motorists to reduce their consumption of fuel. However, there would probably be high transaction costs associated with this approach.
- Refineries. Refineries located in the region of the scheme, would have to buy permits to cover the emissions generated when the fuel that they produce is used in vehicles. It would probably be necessary to couple this approach with border adjustments to the price of imported fuel to avoid carbon leakage. Border adjustments are discussed in detail in Chapter 22.
- Manufacturers. Vehicle manufacturers would be faced with a target for fuel efficiency of the average vehicle sold and, to the extent that they exceeded this target, they would have to buy permits to cover the excess expected lifetime carbon emissions from fuel inefficient vehicles. However, future emissions from these vehicles would be uncertain, making this hard to reconcile with trading schemes based on actual emissions.

The European Commission is currently reviewing the operation of the EU ETS, including whether it should be extended to include other sectors such as road transport.

The inclusion of aviation, road, rail and maritime could increase the size of the EU ETS by up to 50% (such that the EU ETS would cover around 55% of total EU 25 greenhouse emissions, and a larger proportion of total CO_2 emissions), with benefits for liquidity[53].

[53] Estimates based on emission estimates for EU 25 in 2000 from WRI (2006).

Regulatory measures play an important role in the transport sectors in many countries. Vehicle standards – which may be mandatory or voluntary – can put an implicit value on carbon, by restricting the availability of less efficient vehicles. These measures are discussed in more detail in Chapter 17.

In practice, a combination of policies may be justified. Existing policy frameworks and institutional structures in countries will be an important determinant of policy choice. Countries with a history of high fuel taxes, for instance, would need to think very carefully about the public finance implications of switching to trading with free allocations; voluntary standards might be very effective in countries with a strong tradition of co-operation between government and business, but much less so in countries with a different culture.

As in other sectors, climate change is not the only market failure in the transport sector and there are important interactions with other policy goals. Congestion, for instance, imposes external costs on other motorists by increasing their journey time. Congestion pricing and carbon pricing are very similar approaches from an economic point of view - they both price for an externality. Congestion charging could have a positive or negative impact on carbon emissions from transport, depending on how the instrument is designed and level at which the charge is set.

Aviation

Aviation faces some difficult challenges. Whilst there is potential for incremental improvements in efficiency to continue, more radical options for emissions cuts are very limited. The international nature of aviation also makes the choice of carbon pricing instrument complex. Internationally coordinated taxes are difficult to implement, since it is contrary to International Civil Aviation Organisation (ICAO) rules to levy fuel tax on fuel carried on international services[54]. The majority of the many bilateral air service agreements that regulate international air services also forbid taxation of fuel taken on board. Partly for this reason, levels of taxation in the aviation sector globally are currently low relative to road transport fuel taxes. This contributes to congestion and capacity limits at airports – a form of rationing, which is an inefficient way of regulating demand.

While either tax or trading would, in principle, be effective ways to price emissions from this sector, the choice of tax, trading or other instruments is likely to be driven as much by political viability as by the economics. Chapter 22 will discuss further the issues of international co-ordination of policy in this area (as well as in shipping, which faces similar issues). A lack of international co-ordination could lead to serious carbon leakage issues, as aircraft would have incentives to fuel up in countries without a carbon price in place.

The level of the carbon price faced by aviation should reflect the full contribution of emissions from aviation to climate change. As outlined in Box 15.6, the impact of aviation on the global warming (radiatiive forcing) effect is expected to be two to four times higher than the impact of the CO_2 emissions alone by 2050. This should be taken into account, either through the design of a tax or trading scheme, through both in tandem, or by using additional complementary measures.

[54] Article 24 of Chicago Convention exempts fuel for international services from fuel duty. See ICAO (2006).

Box 15.6 The impact of aviation on climate change

Aviation CO_2 emissions currently account for 0.7 Gt CO_2[55] (1.6% of global GHG emissions). However the impact of aviation on climate change is greater than these figures suggest because of other gases released by aircraft and their effects at high altitude. For example, water vapour emitted at high altitude often triggers the formation of condensation trails, which tend to warm the earth's surface. There is also a highly uncertain global warming effect from cirrus clouds (clouds of ice crystals) that can be created by aircraft.

In 2050 under 'business as usual' projections, CO_2 emissions from aviation would represent 2.5% of global GHG emissions[56]. However taking into account the non-CO_2 effects of aviation would mean that it would account for around 5% of the total warming effect (radiative forcing) in 2050[57].

The uncertainties over the overall impact of aviation on climate change mean that there is currently no internationally recognised method of converting CO2 emissions into the full CO2 equivalent quantity.

Agriculture and land use

Agricultural emissions come from a large number of small emitters (farms), over three quarters of which are in developing and transition economies. Emissions from agriculture depend on the specific farming practices employed and the local environment conditions. Since the sources tend to be distributed, there would be high transaction costs associated with actual measurement of GHG at the point of emission.

An alternative approach in this sector would be to focus on pricing GHG emission 'proxies'. For example, excessive use of fertiliser or high nutrient livestock feeds is associated with high emissions, but by appropriate pricing, emissions can be reduced. However in practice, in many developing countries fertiliser is actually subsidised, largely to support the incomes of farmers. In many countries it is a somewhat regressive subsidy, as it is the richer farmers or agribusinesses who gain most.

Difficulties associated with measuring emissions are also the reason why it is difficult to incorporate GHG emissions from agriculture into a trading scheme. However there are examples of projects that have overcome these problems and enabled farmers who adopt sustainable agriculture practices, to sell their emission savings on to others via voluntary schemes; this issue is discussed further in Chapter 25.

Inadequate water pricing can intensify the problems of weak fertiliser pricing, since water and fertiliser are complementary inputs – additional fertiliser works much better with stronger irrigation.

Many countries have adopted regulation of agricultural practices. For example, regulations for the use of water in growing rice, the quantity and type of fertiliser used in crop production, or the treatment of manure. Regulations are often location specific, because local conditions influence best practice. However, in developing countries, enforcement of regulations can be difficult because they may not have the institutional structures or resources to allocate to this task. Better pricing of inputs is generally a preferable route: income support to poor farmers or agricultural workers can be organised in much better ways than subsidised inputs.

[55] WRI (2005).
[56] Aviation BAU CO2 emissions in 2050 estimated at 2.3 GtCO2, from WBCSD (2004). Total GHG emissions in 2050 estimated at 84 GtCO2e (for discussion of how calculated, see Chapter 7).
[57] IPCC (1999). This assumes that the warming effect (radiative forcing) of aviation is 2 to 4 times greater than the effect of the CO2 emissions alone. This could be an overestimate because recent research by Sausen et al (2005) suggests the warming ratio is closer to 2. It could be an underestimate because both estimates exclude the highly uncertain possible warming effects of cirrus clouds.

There are complex challenges involved with the inclusion of deforestation, the major cause of land use emissions, in carbon trading schemes. These are discussed in detail in Chapter 25.

15.6 Conclusions

Chapter 14 discussed how, at the global level, policymakers need both a shared understanding of a long-run stabilisation goal, and the flexibility to revise short-run policies over time.

At the national – or regional level – policy makers will want to achieve these goals in a way that builds on existing policies, and creates confidence in the future existence of a carbon price. In particular, they will want to assess how carbon pricing (through either taxation, tradable quotas or regulation) will interact with existing market structures, and existing policies (for instance, to encourage the development of renewable energy or petrol taxes).

Governments will want to tailor a package of measures that suits their specific circumstances. Some may choose to focus on regional trading initiatives, others on taxation and others may make greater use of regulation. The key goal of policy should be to establish common incentives across different sectors, using the most appropriate mechanism for a particular sector. With market failures elsewhere, other objectives, and the costs of adjustment associated with long-lived capital, it will be important to look at both the simple price or tax options as well as quotas and regulation to see what incentives in particular sectors really work.

Carbon pricing is only one element of a policy approach to climate change. The following two chapters discuss the role of technology policy, and policies to influence attitudes and behaviours, particularly in regard to energy efficiency. All three elements are important to achieve lowest cost emissions reductions.

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