UNIVERSITY OF CAMBRIDGE
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TACKLING CARBON

HOW TO PRICE CARBON FOR CLIMATE POLICY

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VERSION 1.1
COMMENTS WELCOME

Carbon emissions from energy production and industrial processes are deeply entrenched in our economies. To mitigate the risk of catastrophic climate change they need to be reduced to a fraction of today's level. The challenge for climate policy is to deliver these emissions reductions.

Carbon prices play an essential role. They create incentives for all players in the economy to look for their opportunity to tackle carbon – without committing a foul against economic performance or social wellbeing.

Emissions trading is a viable approach to deliver carbon prices. The details of the implementation of this approach deserve particular attention, as they guide the investment strategies of households, firms and technology developers. The experience with the European Union *Emissions Trading Scheme shows a clear focus on delivering the price is important. Any additional policy objectives should be pursued with other instruments.*

Ambitious countries will implement high carbon prices in order to challenge their industries to be the first to develop low-carbon strategies and technologies. But will industries accept the challenge, or will they relocate to countries where carbon prices are lower? Detailed analysis suggests that concerns only apply to few sub-sectors where they can be addressed through specific instruments.

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Tackling carbon - How to price carbon for climate policy

Climate Strategies

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Preface

Pricing carbon has become widely acknowledged as a central pillar in international efforts to tackle climate change. Economists have argued for many years that the problem cannot be effectively and efficiently tackled, until the myriad decisions through which we emit carbon factor in the environmental costs. Furthermore, pricing carbon would provide an incentive for companies to invest seriously in low carbon innovations.

The basic theory is the easy part. Putting it into practice is much tougher – so tough and politically complex that in many parts of the world, the topic remained pretty much a taboo in terms of public policy until recently. But that is changing. A cascade of analyses culminating in 2006 convinced most of the remaining doubters that something serious had to be done about climate change. Cap-and-trade schemes that generate a carbon price are in discussion in many regions; and the first of these, the European system, is growing up from its pilot phases, with breathing space to consider the lessons and its redesign for the long haul post-2012.

What's been missing in the literature to date is a comprehensive analysis that combines theory with the emerging practical experience and the live policy debates. This study thus offers a timely contribution; and it would be hard to find a more appropriate author than Karsten Neuhoff. He is one of Europe's leading applied economists, and he has specialised in the design of carbon policy for many years. He brings to the field not only a deep understanding of the economic principles, but also a detailed knowledge of the lessons from experience to date, with a sharp eye to some of the realities – both economic and political – that distinguish practical policy from the normal theories.

It was for these reasons that Karsten Neuhoff has been the lead researcher for a series of projects convened by Climate Strategies, an international network organisation established to convene applied research projects that inform climate-change policymaking. Karsten's research had already helped to put the Cambridge University Electricity Policy Research Group on the map of applied research in Europe. The research that he spearheaded for Climate Strategies provided critical input to the development of European policy, and indeed formed a key part of the Climate Strategies initial research portfolio.

This study draws together many themes of Karsten's work with the Electricity Policy Research Group and Climate Strategies over the past few years, in exploring the theory, practical application – and limits – of carbon pricing. The views expressed are his own, but they have been enriched by his interactions with - and have in turn influenced the thinking of – several other leading researchers engaged in the Climate Strategies projects on emissions trading. This study overall contains a rich array of insights and analysis from a leading researcher at the interface of research and policy. Anyone seeking to understand the wide range of issues around carbon pricing should not be without it.

Professor Michael Grubb

Chief Economist, the Carbon Trust; Senior Research Associate, Cambridge Faculty of Economics; and Chairman, Climate Strategies

Introduction

The Intergovernmental Panel on Climate Change (IPCC) concluded, based on the scientific evidence it collected, that global CO_2 emissions have to be reduced to half of today's levels by 2050 to limit the risk of temperatures increasing above 2 degrees (IPCC 2007). Subsequently the G8 leaders agreed on the need for the world to cut carbon emissions by at least 50 percent by 2050 and for each nation to set its own target for a nearer term (Tōyako 2008). The challenge is now to implement policy instruments to deliver the necessary emissions reductions. The Stern Review on climate change points to three sets of instruments (Stern Review 2006): (i) putting a price on carbon; (ii) technology policy and targeted regulation with transparent and shared information; and (iii) engagement of individuals and firms in climate activities. The focus of this book is on the role and implementation of carbon pricing.

Chapter 1 explains the rationale for using carbon pricing; namely it creates incentives for the use and innovation of more carbon efficient technologies, and induces substitution towards lower carbon fuels, products and services by industry and final consumers. The price signal feeds into individual decisions that would be difficult to target with regulation. It also makes it profitable to comply with carbon-efficiency regulations, thus facilitating their implementation. Carbon prices can be delivered with a carbon tax or cap and trade schemes. The relative merits of both approaches are discussed throughout the book.

Chapter 2 focuses on the implementation of carbon pricing using cap and trade schemes. It draws on the early experience of trading schemes for SO_2 and NO_X in the US and the subsequent European Union Emissions Trading Scheme (EU ETS) for CO_2 allowances. Cap and trade schemes can gain support from stakeholders, aid coordination across countries, and deliver a carbon price. After initial difficulties, support for the EU ETS is now widely shared across governments, industry and political groups. However, the experience of the first years also offers several insights. The implementation of a scheme that allocates allowances with an annual value of about 40 billion Euro is not trivial.

Free allowance allocation to emitters turned out to be the Achilles heel of the pilot phase, which operated from 2005 to 2007. Allocating allowances for free intensifies lobbying and can inflate the cap. Repeated free allocation also creates various perverse incentives that undermine the economic efficiency of the scheme. Therefore the European Commission has proposed to auction most allowances in the European scheme post-2012.

Free allocation to emitters can also have undesired distributional impacts. In most markets emitters will pass carbon costs onto product prices and thus to consumers. As a result emitters profit from the free allocation, while consumers bear the costs. Schemes to compensate households for the distributional implications of carbon pricing deserve careful consideration to ensure equity and political support. The negative public perception of large emitters benefiting from free allowance allocation was the second reason to move towards large scale auctioning in Europe post 2012, but might have also contributed in to lower shares of free allocation to emitters and clearly defined transition towards full auctioning envisaged in schemes discussed in other countries.

Large scale emissions reductions – with continued economic prosperity – cannot be delivered by operational choices alone. They require changes to investment choices. Chapter 3 discusses determinants for investment towards low-carbon infrastructure and production processes. Investors will only pursue these choices on a significant scale that can deliver large scale emissions reductions if they are profitable. As investor types differ, the emission trading scheme has to accommodate their different needs.

Investors in low carbon projects are particularly concerned about the impact of low carbon prices. A scheme that reduces the risk of extremely low carbon prices thus facilitates low-carbon investment. In contrast, for strategic decisions on investment in infrastructure, new product lines and technology development, today's price signal is not sufficient. A shared and consistent vision of the decarbonisation trajectory and targets is required, and needs to be complemented with an appropriate policy mix and tangible evidence of government commitment.

A cap and trade scheme can meet the needs of such different investors. For example under EU ETS for the short-term an increasingly robust carbon price is evolving. Instruments to avoid the small risk of extremely low prices are available: Governments can implement reserve prices in auctions or issue long-term put options on carbon prices. Looking towards 2020, European governments have committed to a clear emissions target, and thus offer strategic investors confidence in market opportunities for low-carbon processes, products and services. The cap and trade scheme defined for the same time frame allows the carbon price to respond to changes in fuel and commodity prices or technology costs and thus contributes to the delivery and credibility of the target.

This raises the more general question: should countries with higher levels of public support for ambitious climate policies commit to ambitious targets and implement corresponding measures or should they wait for other countries to jointly pursue climate policy at a common level of ambition?

Chapter 4 approaches this question first with evidence from a national level. Do countries pursue the same type and stringency of climate policy across different sectors? The chapter identifies a multitude of aspects that influence, for example, the decision to include a sector in an emission trading scheme. They include the role of pre-existing taxation, the importance that carbon pricing has in the sector to trigger innovation and substitution to low carbon alternatives, distributional implications and transaction costs. Emissions trading schemes developed in different countries include different sets of sectors. This illustrates the differences in circumstances and judgements across countries.

It leads to the question of whether different countries should implement a joint emissions trading scheme? Such a joint scheme can leverage static efficiency gains – allowing traders to identify the least cost emission reduction opportunities. A joint scheme also has some political attractions – it might reflect a larger commitment of participating countries and could create a momentum that drives the implementation through adverse political circumstances.

The benefits have to be weighted against three drawbacks: First, if two countries have a joint scheme, but negotiate the next set of emission targets separately, then industry in the more ambitious country will end up buying allowances issued from the less ambitious country. This creates strong incentives to negotiate less ambitious targets. Second, emission reductions require a multitude of domestic policies, like information provision, performance standards, and suitable regulatory frameworks for new technologies. Their implementation is improved, if national or regional governments can measure and manage the success of these policies against emission targets and trajectories. The responsibility of governments is more clearly defined if it coincides with the boundaries of an emission trading scheme. Third, if domestic support in a country allows for more ambitious climate policy, then a tighter cap results in higher carbon prices and accelerates low carbon innovation and transformation. As the new low carbon process, products and policies diffuse to other regions, they contribute to an accelerated global decarbonisation.

Currently separate emission trading schemes are evolving in Australia, New Zealand, and some US states while European countries have implemented a joint trading scheme. Several approaches are available that could result in direct and indirect linking of these schemes. It is for policy makers to decide whether to pursue early linking towards an integrated scheme or whether to delay such linking to 2020. Even where schemes are not initially linked, the international framework remains important. The European experience illustrated the value for example of the external commitment to the Kyoto targets for the national and European political process.

A second motivation for an international framework is the ‘common but differentiated’ responsibility of all countries for climate policy, as confirmed at the international negotiations in Bali (UNFCCC 2008). The differentiated nature of the responsibility not only reflects the responsibility for more ambitious climate policy by developed countries, but also a joint responsibility of developed and developing countries to work together towards reducing emissions in developing countries.

The Clean Development Mechanism (CDM) has been a first step. It allows companies and governments in developed countries to invest in carbon savings projects in developing countries and gain credits for the savings and thus demonstrate how low-carbon projects can be pursued with financial support from developed countries. But the approach is not satisfactory if the scale of the cooperation is to grow. The current CDM approach subsidises individual low-carbon projects, in the future cooperation should also provide technical and financial support for the implementation of low-carbon policies.

An international framework that supports cooperation with developing countries and encourages ambitious countries to take leadership in ambitious climate policy has many attractions. It not only results in higher direct emissions reductions in the more ambitious countries, but it can also accelerate technological development and create experience with low carbon policies and institutions.

However, a world with asymmetric carbon prices frequently raises concerns about carbon leakage: Higher carbon prices might induce some industries to shift production or investment to countries with low or no carbon pricing. The direct emissions effect if the new production is more carbon intensive or additional carbon emissions are created with additional transportation is likely to be limited, and could even be negative if new installations apply best available technology. The indirect emissions effect is more disconcerting: As some production is relocated, the emissions are no longer accounted for under the cap of the respective trading scheme. Thus other sectors can reduce their decarbonisation efforts and use the freed up allowances. Some of the production will be replaced by production in countries that have not committed to an ambitious emission reduction target and will thus increase emissions in that country. Thus global emissions would increase.

Chapter 5 shows that for 98%-99% of economic activities the cost increase from carbon pricing is trivial relative to other cost components. Only in 24 sub-sectors the cost increases from carbon emissions are significant. Because of factors like transport costs, product differentiation, and sunk investment costs there is no concern about leakage in several of these sub-sectors. Thus only a few sub-sectors, like basic steel and cement production, are likely to require targeted measures to address leakage concerns. These measures can differ across sub-sectors and can include conditional free allowance allocation, state aid and border adjustments. Government lead sectoral agreements are often mentioned as a further measure, but it might be politically preferable and more effective to use them to cooperate on emission reductions. All options have significant negative side effects, and should therefore be applied as restrictively as possible. If they are implemented in an internationally coordinated approach, some of these negative effects can be reduced. Close international cooperation will therefore be essential to ensure any response to leakage protects the environmental effectiveness of carbon pricing.

It is possible for countries to pursue ambitious emissions targets and make use of the full carbon price signal as part of their policy mix. Leading by example can help to accelerate international processes – and should therefore be facilitated in any international framework on climate policy. But it is not a substitute for an international agreement that reflects the common but differentiated responsibility, provides time-frames and commitments for the implementation and enforcement of domestic policies, and guides the cooperation between developed and developing countries on mitigation and adaptation.

1 The economic rationale for carbon pricing

Key points:

- *Carbon pricing, technology policy and regulation are the pillars of climate policy.*
- *Carbon pricing rewards individuals and firms that reduce emissions.*
- *It also creates market potential for low carbon and energy efficient innovation.*
- *To deliver this outcome the carbon price has to feed through the economy.*
- *This builds on extensive empirical evidence: energy prices drive energy efficiency.*
- *Distributional implications for low income households need to be addressed.*

→ *Carbon pricing is a challenging, but indispensable, component of climate policy.*

This chapter discusses three ways in which carbon pricing can contribute to emissions reductions. First, carbon pricing will shift production towards using low-carbon and more energy efficient technologies. Second, high carbon input factors, products, and services will be substituted with less carbon-intensive alternatives. Third, this change in turn creates incentives for innovation and development of lower carbon technologies, products and services.

The first evaluations of the link between the European Union Emissions Trading Scheme and carbon emissions of our economies suggest that already in 2005 the scheme reduced emissions of installations covered by the scheme by about 2.5%-5% (Ellerman and Buchner 2007).. However, data is still scarce and therefore estimation uncertainties are large, particularly for the evaluation of long-term impacts. To consider other evidence, we turn to the fact that most carbon emissions result from energy consumption. Data on the link between energy prices and energy consumption offers some insights on the effect that can be expected from carbon pricing. Figure 1.1 depicts the average energy prices and the energy required to produce one unit of gross domestic product (GDP) for all OECD countries. It shows that countries with higher energy prices deliver more GDP per unit of energy input. For example, Japanese firms and households face twice the energy prices of their counterparts in the USA and they deliver twice the GDP with one unit of energy. Analysing energy consumption across sectors, countries and time suggests that doubling of energy prices results in about 50%-70% higher GDP per unit of energy consumed.[1]

This relationship would suggest that our economies can deliver the ambitious emissions reductions required to stabilise global temperatures without jeopardising economic performance. Why not translate the link between high energy prices and high economic output per unit of energy into a link between high carbon prices and high GDP per unit of carbon? Our economies could grow while reducing emissions to sustainable levels. This is confirmed by many models simulating future scenarios of global economic growth with and without carbon policies.[2] Stringent carbon policies would at most reduce the GDP in 2030 by 3% percent, with many models suggesting an even smaller reduction (IPCC 2007).

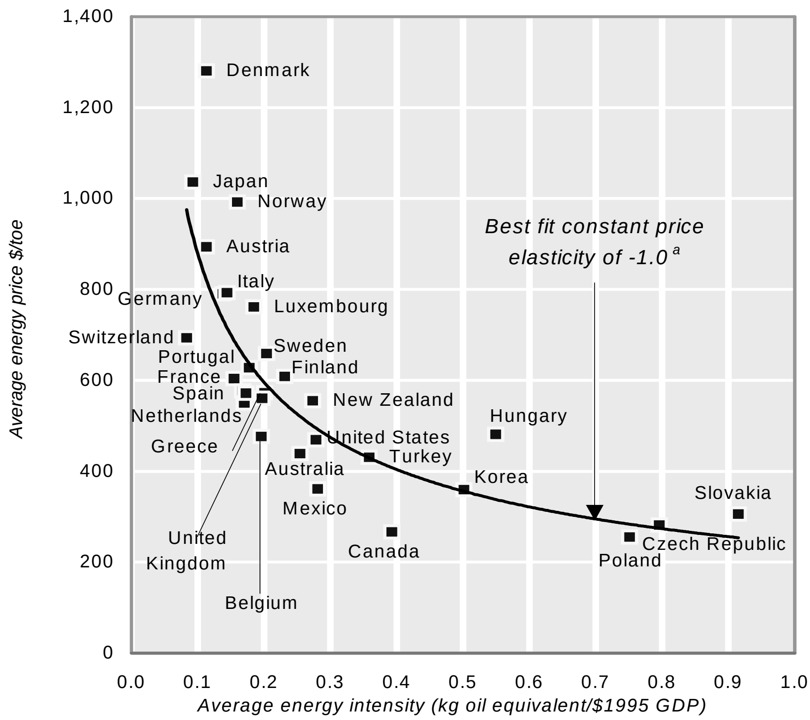

Figure 1.1 Relationship between the energy intensity of an economy and average energy prices, Source (Newbery 2003).

To deliver emissions reductions at these low costs, the models assume efficient use of policy instruments. Discussing, selecting, implementing, executing and evolving the set of policy instruments suitable for different sectors and national circumstances will be no trivial task. Yet, the constructive engagement of individuals across industry, government and academia in debates on policy instruments, and more tangible results like the EU ETS, suggest that the task can be achieved.

Although the focus here is on carbon pricing, other components of climate policy are equally important. Assuming that a high carbon price would single-handedly cause economies to become less carbon intensive would ignore three important aspects of the debate:

First, in addition to differences in energy resources, much of the difference in energy price between countries is explained by different energy policies and, in particular, energy taxation. Implementing a carbon tax or emissions trading will result in transfers between households on different income levels. The implementation of carbon prices is therefore politically sensitive. Careful compensation is required to retain support for climate policy (see chapter 2).

Second, differences across countries result from investment choices that government, industry and households have made over preceding decades. The existing capital stock will take some time to adjust to the impact of climate policies. Credibility about the evolution of carbon policy and pricing will be important to ensure that during this period investment decisions reflect the implied and anticipate the future carbon costs (chapter 3). For many private, public and corporate decisions, carbon costs only play a marginal role and do therefore not capture the attention of decision makers. Also, often the investors in commercial projects and houses do not bear the carbon costs of their future operation. For these reasons complementary policies play an important role in shaping this transition.

Third, as mentioned in the introduction, this raises the question whether some countries can implement more ambitious reduction targets with higher carbon prices, or whether all countries should pursue policies at levels that can be globally agreed.

1.1 Using low-carbon technologies

The most commonly used framework for assessing the opportunity to reduce carbon emissions in our economies are marginal abatement cost curves. Figure 1.2 depicts the potential emissions reductions that can be delivered with different technical measures, where the vertical axis shows for each measure the estimated costs of reducing one unit of CO_2. All the measures towards the left side of figure 1.2, such as insulation of buildings and water-tanks, have 'negative abatement' costs: the energy savings that can be achieved exceed the investment costs for improved building insulation or efficient lighting systems. This is reflected in the conclusions of a recent EU green paper on energy efficiency: At least 20 % of energy could be saved in a cost-effective manner (European Commission 2005).

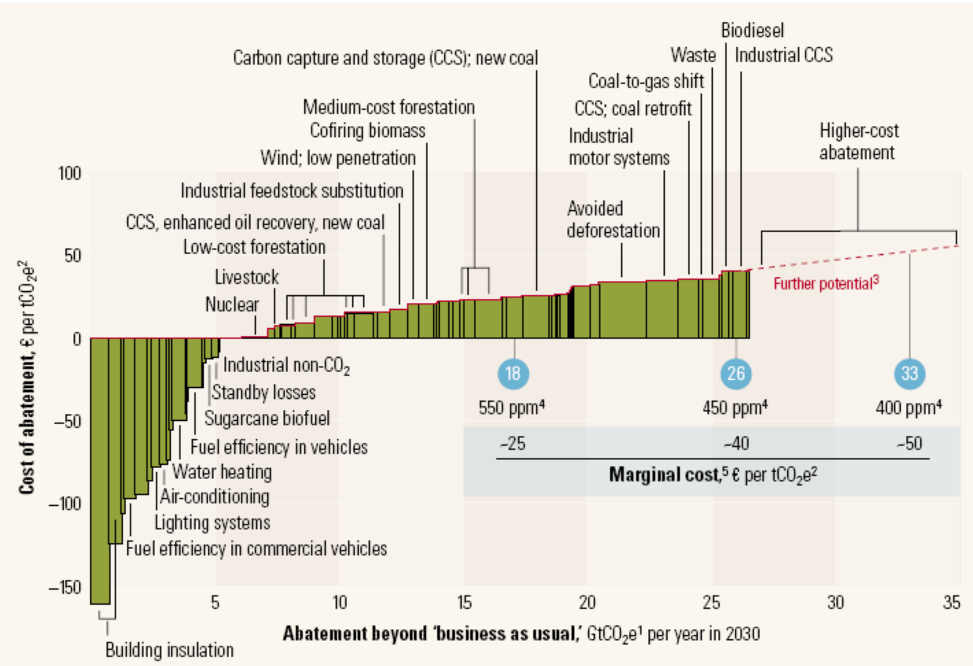

Figure 1.2 Marginal abatement cost curve (Enkvist et al 2007)

An extensive set of economic, sociological and policy studies have examined why these profitable opportunities to save energy and carbon emissions have not been realised. The main barriers that have been identified include lack of information and interest, lack of access to low-carbon products, and lack of credit to finance the upfront investment in energy efficiency and insulation. [3] Institutional misalignments also create barriers between investors and beneficiaries. These are exemplified by the tenant-landlord relationship: the landlord has to pay for insulation but only the tenant benefits from lower heating bills. Governments are increasingly implementing policies to address these market failures and realise low cost opportunities to reduce energy consumption and carbon emissions.[4]

Many measures are cost-effective even without a carbon price and could be implemented once the various barriers are removed. This leads to the question what role does carbon pricing play in promoting the use of low-carbon technologies?

First, additional opportunities to reduce carbon emissions are cost effective as carbon prices make alternatives more expensive, and so measures that require a positive carbon price can then be implemented. In particular, carbon capture and sequestration is more expensive than other conventional approaches. It requires plants to satisfy additional design criteria and to be equipped with compression facilities, and the captured carbon must be transported to geological storage sites. Thus carbon capture and sequestration will only be utilised where conventional technologies which produce carbon emissions, face higher costs from carbon pricing. In theory the prohibition of high carbon technologies could also provide incentives for investment in low-carbon technologies. But such regulation is unlikely to be able to micro-manage all carbon and energy related activities efficiently. Regulation will therefore be a complement to, rather than a substitute for, carbon pricing.

Second, carbon pricing will increasingly impact on decision making processes. The more profitable these measures are, the more likely it is that they will receive attention and will be implemented. But often additional management attention is required. The design, implementation, and visibility of emissions trading with reporting requirements and compliance obligations can contribute to focusing management’s attention on implementing energy efficiency or direct carbon emissions reduction measures.

Third, it is often argued that governments should prescribe measures to improve energy efficiency and emissions reductions rather than use carbon prices. But such measures are often only cost effective for private agents if a carbon price is implemented, and so carbon price facilitates the enforcement of additional regulations.[5] This shows that tailored regulation is a complement to carbon pricing rather than a substitute for it.[6]

Fourth, regulation prescribing or subsidising the use of energy efficient or low-carbon technologies might have a reduced effect without carbon pricing as a complement because of the ‘rebound effect’. The increased efficiency from insulation of houses, for example, reduces fuel consumption and heating costs in cold climates or air-conditioning costs in hot climates. In response, in the case of heating, some households will increase room temperatures, heat rooms for longer periods, and might not bother to turn down the heat when they are out of the house. Thus, the envisaged energy demand reduction from efficiency measures would be partially offset by a 'rebound effect'. Carbon pricing compensates for the reduced fuel costs and discourages a rebound effect.[7]

In summary, carbon pricing improves the cost effectiveness of low-carbon and energy efficiency technologies, and extends the wider application of these technologies. Many energy efficiency measures are not implemented despite their cost effectiveness, which suggests a need for complementary measures to overcome the barriers that restrict their use. Finally, a carbon price mitigates concern about the rebound effect.

1.2 Replacing high carbon fuels and commodities

Improving energy and carbon-efficiency of production and provision of energy services is unlikely to provide the necessary emissions reductions on its own. Figure 1.3 illustrates the carbon emissions from different sectors of the UK economy. The world's leading climate scientists (IPCC 2007) hold the view that developed countries have to reduce emissions by 60% to 80% to stabilise global temperatures. As further economic growth is expected in this time frame, the real emissions reductions that need to be achieved will be even larger compared to a business-as-usual (BAU) scenario.

To deliver these reductions all economic sectors will have to contribute. Technology and efficiency improvements are likely to play an important part in these emissions reductions. It is, however, likely that consumption of some carbon intensive products, such as cement, steel, and aluminium, will have to be reduced. This reduced consumption could be achieved either by using products more efficiently, or by substituting other materials. This implies that sectors with carbon-intensive products or services (e.g. air transport) will become less important in the overall economy. This is a political economy challenge: in many discussions on climate policy these carbon-intensive sectors lobby policy makers to grant exemptions.

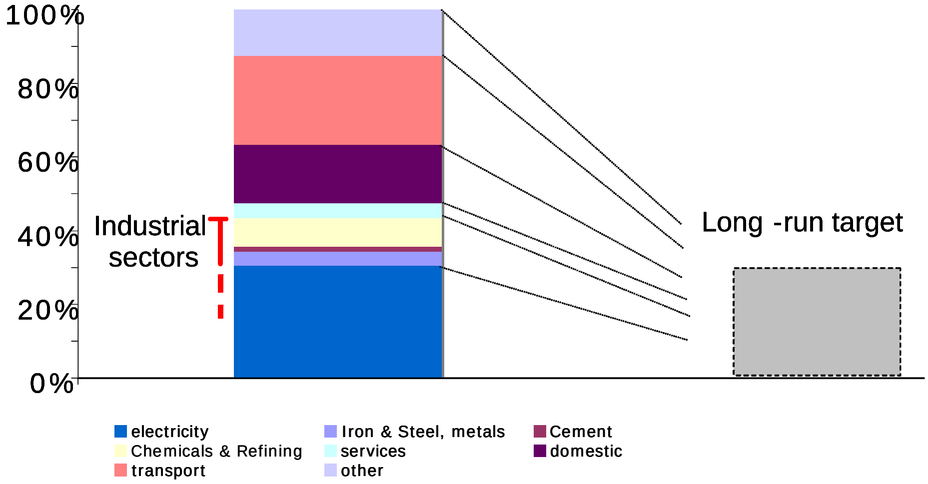

Figure 1.3 Sectoral carbon emissions in the UK. Source: Based on (National Atmospheric Emissions Inventory 2004).

1.2.1 Substitution of input factors

The substitution of carbon-intensive input factors with low-carbon alternatives should be a main facilitator in reducing emissions. For example in the electricity sector, burning natural gas instead of coal for power generation can reduce carbon emissions by about 50% per unit of electricity produced. Moving towards renewable energy sources can virtually eliminate emissions during operation of the plants.

In some instances the use of, or investment in, conventional technology can be prohibited by regulation. For example the European IPPC Directive effectively prohibits the use of mercury as a catalyst in chlorine production post 2007.[8] But such outright prohibition is difficult to envisage for carbon. As prohibition is not possible, policies must seek to reduce carbon emissions without totally banning them. Regulation can deliver this objective in many instances, e.g. by requiring energy efficiency standards for refrigerators.

In the power sector it is more difficult to design direct regulation that would achieve similar effects as the carbon price signal. The amount of electricity produced from carbon-intensive coal power stations will decline and will probably be replaced by renewable technologies. As the output of many renewable technologies depends on wind, sun or water conditions, increasing demand responsiveness and storage will be required. Nonetheless, existing conventional coal power stations are likely to remain on the system and provide power for a few critical hours per year. Carbon prices can ensure that it will not be economical to produce energy using coal power stations beyond a limited amount that is necessary to meet the peak demand. With conventional regulation this would be more difficult to prescribe. How could a government determine ex-ante the number of 'critical hours' for which a power station should be allowed to operate, since this figure will depend on factors like the amount of renewable generation, the generation mix, and perhaps even the climatic condition of a specific year.

1.2.2 Substitution in the value chain

Commodities often progress through many production steps before the final service is delivered to consumers. Some substitution is possible at all steps, but it is difficult to prescribe it with regulation. We refer to the consecutive production steps as the value chain – and will illustrate the substitution opportunities using the example of clinker, the main component of cement.

Clinker is produced by heating lime stone, which undergoes a chemical transformation releasing carbon. Although carbon emissions can be reduced by using renewable energy sources for heating, the majority of the emissions are due to the chemical transformation and cannot be avoided. After milling, clinker is mixed with other substances to make cement. Here the main scope for reducing emissions is via the substitution of some of the clinker with other materials suitable for cement production.[9] Cement is then used to create concrete structures. With more careful planning and execution, cement structures can be made leaner by substituting material costs with additional labour costs. Architects and engineers can choose between various materials such as concrete, steel, wood, stone and glass, and so strike a balance between cost effective material choice and design criteria. If concrete, steel and glass prices reflect the price of carbon then the choice of inputs will shift. Finally, in many developed countries investors face a choice between refurbishing the existing buildings, which is labour intensive, and replacing old buildings with new ones, which is more material intensive. If the price of carbon is reflected in the prices of materials, it creates an incentive to refurbish rather than replace buildings.

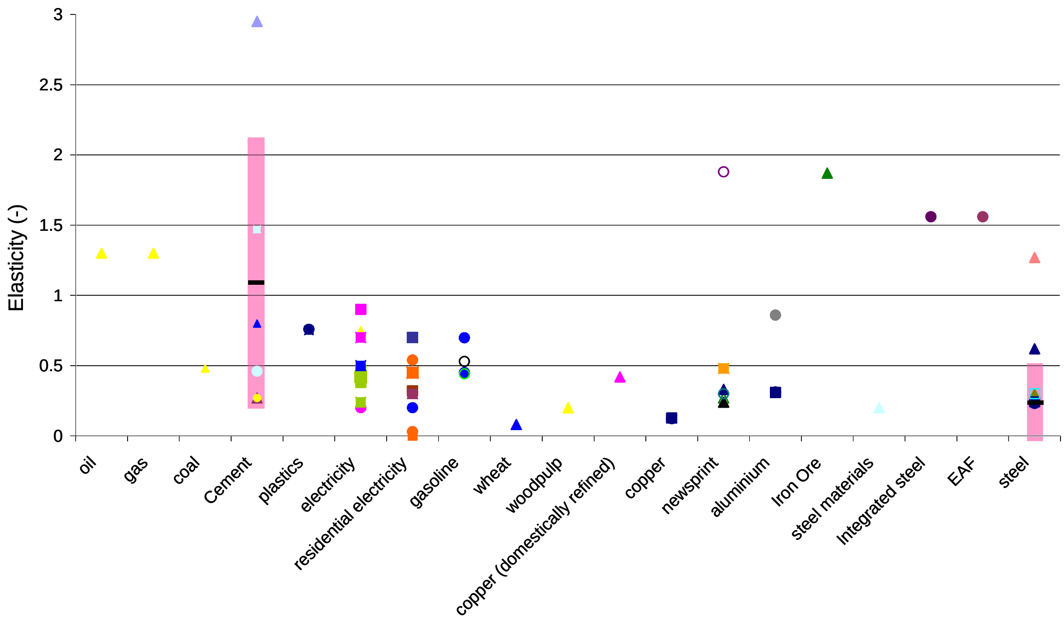

Figure 1.4 Price elasticities of demand for various commodities[10]

The examples illustrate the different substitution opportunities that exist in the value chain. Several studies aim to quantify these substitution effects by determining the price elasticity: if the price of the commodity increases by 10% then a price elasticity of -0.5 implies that demand will fall by 5%, while with a price elasticity of -1.0 the demand will decrease by 10%. One of the challenges for economists is the estimation of such price elasticities. Figure 1.4 depicts the estimation results across various commodities from several studies. The purple bars indicate the results we obtained in a separate estimation and also show the range of uncertainty for some of the estimates.

The reduction for the demand of steel and cement that a carbon pricing policy can deliver is difficult to predict. To provide a first estimate, we calculate for steel and cement the cost and thus price increase from a 20 Euro/t carbon price. We then use estimates for their price elasticity to calculate likely demand reductions. Based on literate values we also estimate the possible emissions reduction from efficiency improvements. The dark bar in figure 1.5 gives the minimum emissions reduction (90% certainty) that can be expected from demand reduction and efficiency reduction. Combined with first grey bar the dark bar gives the median expected emissions reduction, and the combined with both grey bars the maximum emissions reduction expected (90% certainty). The results demonstrate the level of uncertainty associated with current estimates, and also point to the need to pursue both efficiency improvements in the production and to use the carbon price signal to encourage substitution towards lower carbon commodities.

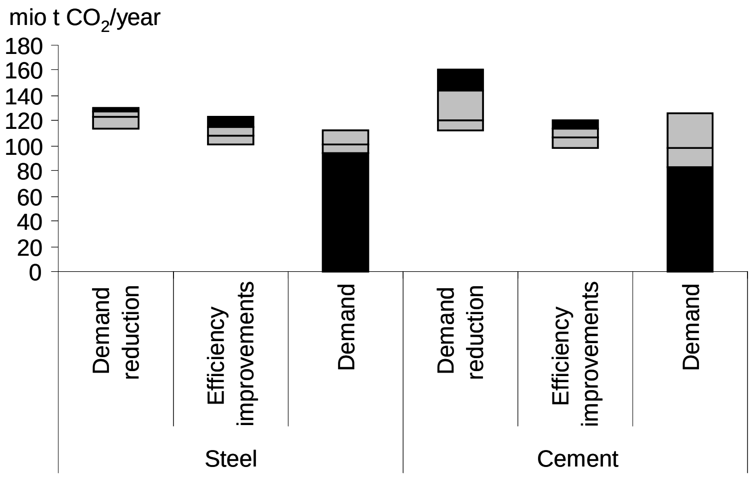

Figure 1.5 EU-25 emissions attributed to steel and cement production in 2005 and expected emissions reductions (grey area gives confidence interval 10% to 90%)[11]

Substitution opportunities involving lower carbon inputs and services exist along the value chain. The carbon price signal will play an important role in realising these opportunities. If carbon prices feed through the value chain, they will also increase the prices for products and services purchased by final consumers. In fact, the substitution effects estimated in this section also reflect the choice made by final consumers and required their exposure to the carbon price signal. This implies that consumers will face higher costs for buying carbon-intensive products and services. The next section examines whether consumers will lose from carbon pricing.

Text box 1: Power sector example

Different technologies can be used to generate electric power. The amount of CO_2 they emit per MWh of electricity generated differs. For example, a combined cycle gas turbine produces about 0.48 tons of CO_2 per MWh of electricity, while a typical existing coal power station emits about 0.95 tons of CO_2 per MWh. Therefore their production costs are also affected to varying degrees by carbon prices. A CO_2 price of €20/tCO_2 increases the generation costs for a gas plant by €9.6/MWh and for the coal plant by €19/MWh.

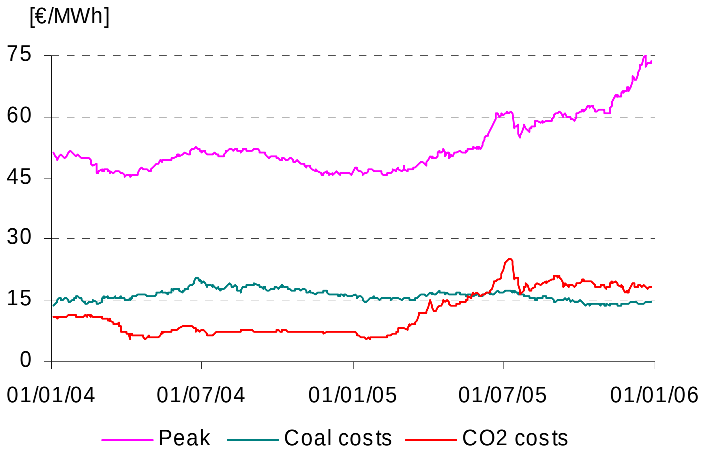

Figure 1.6: Power prices versus fuel/CO2 costs in Germany (year ahead 2003-05) (Sijm et al. 2006)

The price of electricity in competitive markets is set by the most expensive unit that is still required to meet electricity demand. For many continental European markets the marginal units are in most hours coal power stations. Figure 1.6 illustrates how in Germany the price of the one year forward contract for electricity (purple) increased with the implied carbon costs (red), while during this period coal prices stayed constant (green). In countries where gas turbines are setting the marginal power price, like in the UK and The Netherlands, the power price increased roughly in line with their carbon cost of CCGT turbines.

The experience across liberalised markets in Europe has confirmed that carbon costs are passed through to power prices, despite free allocation of allowances. This is because free allowance allocation is a transfer, and allowances can be sold profitably if not used. Power companies will only use allowances to produce electricity if that is more profitable than selling the allowances. This economic rational was not shared by consumers. They complained about the windfall profits of power companies that received allowances for free and subsequently charged higher power prices. These complaints triggered a move towards full auctioning of allowances for the power sector post-2012.

In liberalised power markets all power generators receive the price of the marginal unit. Therefore low-carbon technologies like hydro or nuclear benefit from the electricity price increase. The higher prices are born by final consumers. Governments will have to pursue policies to compensate poor households for higher electricity costs induced by higher carbon prices. The incentives to reduce energy consumption can be retained if initial units of electricity are provided at lower cost (live line tariff), energy efficiency measures are subsidised, or direct transfers are used as a compensation measure.

1.2.3 Balancing the distributional impacts of carbon pricing

A change of prices creates winners and losers. Policies that influence prices therefore have equity implications, which need to be carefully considered to prevent an increase in inequality. Carbon prices create additional costs for industrial producers as well as domestic consumers. The first question to answer is: who bears the costs? In most instances firms can pass industry wide carbon cost increases through to product prices, as intended by carbon pricing. Final consumers will pay higher prices and bear the costs. See the power example in text box one. They are not, however, a homogeneous group, and there is some concern that poorer people will face disproportionate cost increases. Carbon pricing policies create additional revenue streams from carbon taxes or auctions of carbon allowances, and some of these revenues could be used to compensate consumers for the higher costs.

The starting point of the discussion is therefore the question as to what extent industry can pass through carbon costs to product prices. The European experience suggests that for example in liberalised power markets all carbon cost are passed to power prices.[12] If utilities receive allowances for free, they will benefit from the introduction of an emissions trading scheme. In the absence of liberalisation, the regulatory regime matters. For example under cost based regulation, utilities can pass on carbon prices if they incur real costs, but not if they receive emissions allowances for free.

The debate about carbon pass through is livelier in non-power sectors, because it is too early for robust empirical evidence from the European Union Emissions Trading Scheme to resolve the debate.[13] A longer observation period is required because pricing decisions are less transparent, and the carbon price impact is overall smaller. For products like cement, prices are often set in annual contracting rounds, thus delaying the adjustment of product prices with changing carbon prices. While such delays complicate the analysis of carbon price pass through, delays of one or two years have limited relevance for the question who bears the costs in the long term. This leaves two main reasons that could prevent industry producers from passing through the full carbon price.

Firms might not be able to pass on the full carbon cost to their product if competitors succeed in producing the same product less carbon-intensively, or if consumers shift towards lower carbon products and demand falls. This is a desired effect of market based approaches to reduce the profitability of inefficient or undesired products and thus create an incentive for efficient investment and innovation.

The implications of global markets are widely debated. Firms can pass on input cost changes if all competitors face similar cost increases, which has been demonstrated for input factors like oil and commodity prices or exchange rates.[14] But what happens where some of the competitors do not face similar cost increases because they are producing in countries that do not impose carbon prices? Chapter 5 analyses industrial activities in more detail, and points to specific products that face significant cost increases from carbon prices. Where these products are actively traded between regions with and without carbon prices, it will be difficult for firms to pass the full carbon price to product prices.

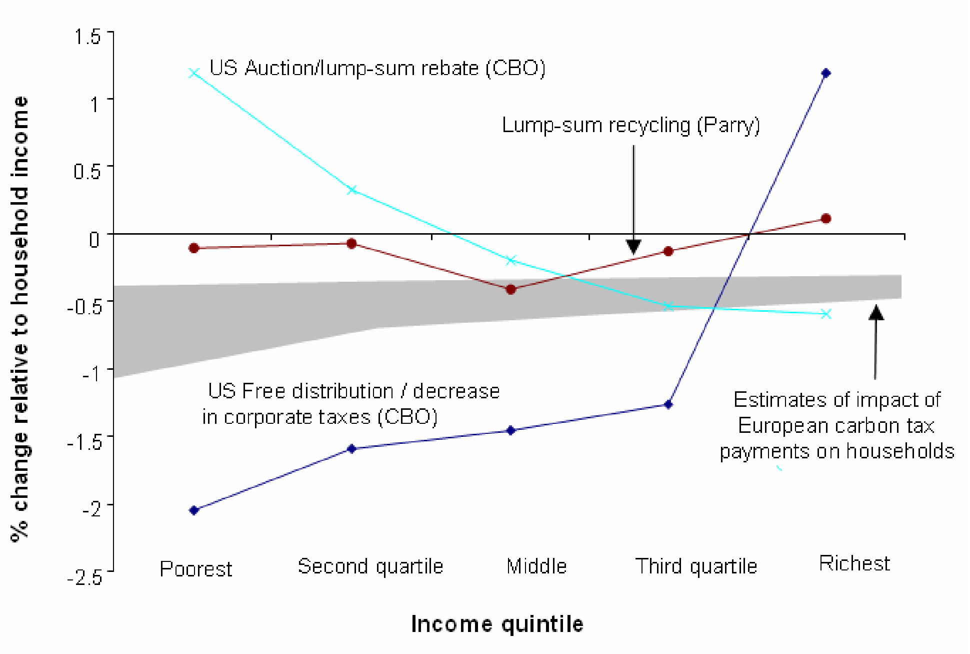

Figure 1.7 Comparison of estimates of carbon tax impacts and redistribution policies, original studies scaled to carbon price of 20 €/tCO_2(Smith 1992; Congressional Budget Office Report 2000; Parry 2004).

What will be the implications of carbon pricing for consumers? Studies typically find that poorer consumers spend a larger fraction of their income on fuel and energy intensive products than rich consumers (Baker and Koehler 1998). Therefore cost increases relative to income are higher for poorer consumers than for richer consumers.[15] Figure 1.7 shows the cost increase different consumer segments face from a carbon price of 20 €/tCO_2 on heating and transport fuels. While they differ across European countries (grey area), the cost increase relative to income is consistently biggest for the low income consumer segments.[16]

What really matters is not the increase on energy expenditure, but the impact after government decides how to redistribute the additional revenue to compensate consumers or industry for their cost increase.

- The Congressional Budget Office (2000) rebate curve studied the impact of distributing the revenue from carbon pricing equally among all citizens. In this case poor consumers will benefit from the introduction of carbon pricing, because they use the least energy and energy intensive products.

- In contrast, if government revenue from carbon pricing is used to reduce corporate taxation the overall distributional implications are regressive – corporate tax reduction curve (Congressional Budget Office Report 2000). Rich consumers own a larger share of firms and thus benefit from the introduction of a carbon pricing scheme with the recycling via corporate tax reductions. Poor consumers bear the cost increases of carbon intensive products and services without compensation, and are thus worse off.

- The analysis by Parry (2004) show that it is possible to carefully balance the use of revenue from carbon pricing so as to avoid any distributional impacts.

Consumer level data still masks differences within consumer segments, such as different transport and housing patterns in urban and rural environments. More generally, consumers choose different products and services, and will therefore be affected differently by carbon pricing. To compensate for the average level of cost increases faced by the consumers in a segment will result in some consumers in a segment benefiting from the introduction of carbon prices while others do not. Compensation schemes would have to be linked to the activities of consumers to ensure all consumers are compensated for their specific energy cost increase. Consumers that spend more of their money on transport would be compensated for their disproportional cost increase under carbon pricing. But such compensation would reward transport usage and undermine the incentive carbon pricing is meant to provide to substitute high-carbon consumption choices with lower carbon products and services.

Thus the different levels of carbon emissions of consumers with similar income levels might become the biggest political challenge for the implementation of ambitious carbon prices. In contrast, the differential impact of carbon pricing on rich and poor consumer segments can be balanced with the revenue created under carbon pricing policies.[17]

1.3 Developing and commercialising low-carbon technologies

Projections for long-term carbon emissions reductions typically include technology improvement and innovation (Edenhofer et al 2006). This section discusses the role of carbon pricing in developing technologies.

Some technologies, for example carbon capture and sequestration, are by their very nature more expensive than conventional technologies. They will only be commercially viable if either a robust carbon price or regulation restricts the use of conventional technologies. Technology companies will only dedicate research effort to develop the technologies if government policy is in place to create viable markets. Given the uncertainties involved in policy processes, early and tangible commitments and policies are likely to be required to create sufficient confidence among investors.

In some cases, modern energy efficient or renewable technologies are more expensive than established conventional technologies. Their costs are expected to fall as producers gain experience in producing the technologies and optimise the design and production, and users integrate the technologies into existing infrastructure.

Carbon prices that increase the cost of conventional technologies will support this learning-by-doing process in three ways. First, they will reduce the cost gap that companies or public subsidies have to cover while the costs of new technologies are above the prices of conventional technologies. Second, with carbon pricing new technologies will be cost competitive with conventional technologies sooner, thus reducing the time over which learning investment occurs. Finally, the profitability of new technologies will be higher in the future as they compete against a more expensive conventional technology. This will increase private sector interest in research, development and commercialisation of these technologies.

Carbon pricing is an important component of technology policy. But is it sufficient to move innovation forward? Despite the legal protection afforded by patents and intellectual property rights, technology analysts and policy makers generally agree that private sector investors do not capture the full benefit of their innovation[18] and therefore under-invest in innovation.[19] To compensate for the uncertainties associated with R&D investment and the frequent spill-over of insights from R&D among companies, countries have implemented tax incentives for research, development and demonstration activities. Governments are discussing further financial incentives and other targeted programs both nationally and internationally.[20]

To support development of low-carbon energy technologies strategic deployment programs must be implemented. For example, renewables can be supported by quotas offering a premium payment or by using feed-in tariffs that guarantee prices for delivered electricity, thus creating markets for technologies that are not yet cost competitive with conventional technologies. The programs are typically intended to (i) support diffusion so as to overcome institutional barriers for new technologies from unsuitable regulation, market design and the planning process; (ii) accelerate low-carbon technology learning; and (iii) directly contribute to energy security of supply and low-carbon objectives.

Some analysts question strategic deployment programs. In their view, governments should not attempt to pick winners. After all, private sector companies have delivered innovation in other sectors. Yet, the ability to appropriate learning benefits varies across sectors. In the mobile telephone or car industry new products offer additional services, which allow companies to charge a premium to finance innovation. In the pharmaceutical industry patents are effective in protecting intellectual property rights. In many other sectors patents can be circumvented, e.g. through small alterations to engineering designs, and thus only offer short-term protection or mainly serve as signalling devices for investors.

Energy technologies have neither of these properties. They offer a largely undifferentiated product, consisting of engineering components, where patents are easily circumvented. In addition, much of the cost reduction is expected to result from mass production. This involves expertise of, and innovation by, many suppliers of manufacturing equipment. It is difficult to envisage how a group of firms could agree on making large scale learning investments when the exact nature of the final technology is not clear. Without the clarity about the nature of the technology it is not possible to write contracts how to share its future benefits.[21]

For technologies where the benefits of innovation are less easy to appropriate, targeted support schemes will therefore be an important complement to carbon pricing. Governments should only support technological innovation (i) where there is transparent and public information about the technologies and their potential, preferably from an international market for these technologies (ii) where government retains sufficient institutional independence to abandon support programs should the technology not satisfy the expectations, and (iii) where the private sector is unlikely to appropriate the benefit of the future innovation and thus is not in a position to finance the learning investment.

The discussion suggests that for some sectors carbon pricing will play a core role in incentivising innovation and diffusing more energy efficient and lower carbon technologies. In other sectors, targeted support schemes are essential, and will benefit from increased long-term credibility deduced from a robust carbon price.

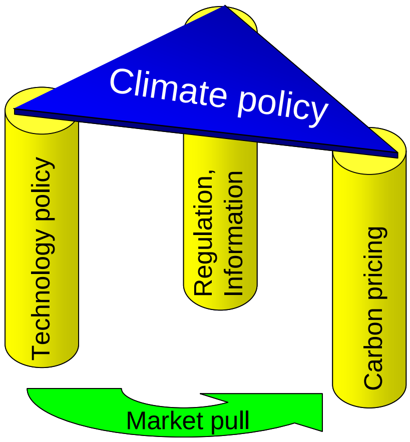

Figure 1.8 Three pillars of climate policy

1.4 Conclusion

Carbon pricing creates incentives for the use of more energy efficient and lower carbon technologies, allows producers and consumers to substitute away from carbon-intensive products and creates some incentives for innovation in low-carbon technologies. Figure 1.8 illustrates that carbon pricing is only one of the pillars of a successful climate policy. It needs to be complemented by two more pillars. The second pillar represents regulation, information provision, institutional set up and other policies that address non-market barriers for increased use of energy efficient and low-carbon technologies and services. The third pillar is technology policy that can range from direct R&D support to strategic deployment programs.

Harvesting the complementarities between the policies will allow for an effective and low cost emissions reduction. As such it will also increase the credibility of the overall decarbonisation strategy. The emphasis given to the different pillars and policies implemented will depend on the national circumstances.

2 Implementing a carbon price

Key messages:

- *Carbon taxes and emissions trading schemes can deliver a carbon price.*
- *Positive experiences with cap and trade schemes in USA and Europe.*
- *Cap setting has to be clearly separated from free allowance allocation.*
- *Repeated free allowance allocation undermines effectiveness of scheme.*
- *Auctioning of allowances ensures stable and technology neutral approach.*

Governments can put a price on carbon either using cap and trade schemes or by imposing a tax on carbon emissions. Both concepts are simple and have been discussed for decades. CO_2 tax schemes were introduced in Sweden in 1991 and subsequently in Denmark, Finland, Netherlands, and Norway, while cap and trade schemes for SO_2 and NO_X have been introduced in the USA. The design of CO_2 cap and trade schemes offered more choices with further reaching implications than anyone expected.

Cap and trade schemes have four basic components. (i) Governments set a cap on the total volume emissions of a pollutant and create the corresponding volume of allowances. (ii) These allowances are distributed for free or sold to firms and individuals. (iii) The allowances can then be freely traded. This creates in principle economic efficiency. Firms that would face high costs to reduce their emissions will buy allowances from firms with lower costs, thus reducing the total costs of emissions reductions. (iv) Emissions are monitored and reported, and at the end of the accounting year, firms either have to surrender allowances proportional to the volume of their emissions to government or can bank them to the following year.

Firms covered by a carbon cap and trade scheme face in principle the full price of carbon emissions. This is obvious where the firm has to buy an allowance from another firm or in an auction directly from the government. Even, however, where firms receive allowances for free, the principle applies. The firm that received a free allowance at the beginning of a trading period has the option of either selling this allowance in the market or using it to cover emissions associated with its production. When using the allowance, the firm will forgo the revenue from selling it. This is the opportunity cost of using allowances that are allocated for free. Section 2.3 discusses how allocation provisions can distort this principle, and can reduce the incentive to improve carbon efficiency of production or undermine the substitution effect.

The alternative approach of a carbon tax requires firms and consumers to pay a tax proportional to the volume of carbon emissions associated with specified activities. Thus in principle carbon taxes have the same effect as cap and trade schemes where allowances are sold by governments. Here the term ‘carbon pricing’ is used to indicate analyses that apply equally to both economic instruments. Differences to cap and trade schemes will be pointed out, in particular with respect to their political economy (this chapter), investment decisions (chapter 3) and international links (chapter 4).

The term ‘emissions trading’ is often used in Europe as a synonym for cap and trade programs, but it also describes schemes without an absolute cap for the total emissions volume such as voluntary trading schemes in the USA. Carbon offsetting programs in developing countries that deliver emissions reductions are also covered by the term emissions trading. Developing countries have not capped their emissions, and therefore do not have cap and trade schemes. They participate in emissions trading via the clean development mechanism (CDM). Under CDM certified projects in developing countries can sell credits from emissions reductions to developed countries that accept these credits within their cap and trade schemes. Thus linkages created by emissions trading can put a price on carbon even in countries that have not capped their emissions. The example also illustrates that emissions trading does not always create a substitution effect. Namely, producers in developing countries do not pay for carbon-intensive production; instead they are paid for investments to reduce emissions. Thus their production costs and competitive product prices do not increase to reflect the carbon price. To the contrary, where the allowance price exceeds the costs of implementing measures to reduce carbon emissions, this provides a subsidy to carbon intensive activities.

This chapter first outlines the fundamentals of cap and trade schemes using the example of the USA’s scheme for SO_2 emissions. The positive experience with these schemes triggered the discussion about the benefits of cap and trade schemes over carbon taxes in domestic climate policy. Section 2.2 describes the background and main features of the European Union Emissions Trading Scheme (EU ETS). Drawing on this experience, section 2.3 discusses lessons that emerge about setting a cap in such a scheme. Section 2.4 describes the lessons that emerge from distortions and inefficiencies associated with different methods of allowance allocation.

2.1 The SO_2 trading program in the USA

SO_2 emissions emerged in the 1950s in a number of industrial countries as a major environmental concern with strong impacts on human health. In response, Japan legislated direct emissions controls for SO_2 in 1962 (Law Concerning Controls on the Emission of Smoke and Soot) that required the use of flue gas desulphurisation for coal plants from 1968. From 1973 a levy on SO_X emissions was imposed that gradually increased to a level of 300 yen/tSO_2 by 1987. The legislative measures at the national level were complemented with agreements between government and industry at regional level.

In the USA SO_2 emissions were first regulated by the 1970 amendments to the 1963 Clean Air Act, which required the use of flue gas desulphurisation for new coal power plants (called the New Source Performance Standard). Similar requirements for existing plants could not be implemented, and as a result it was often more profitable to continue the operation of old power stations than to build new plants that had to comply with the more stringent standards required for upgrades or new investments. This created a disincentive for the replacement or upgrading of old plants.

Cap and trade was first implemented in the USA with the Clean Air Act of 1990 for SO_2 emissions from large emitters. The scheme created a cap for total SO_2 emissions which allowed government to compensate existing plants with some free allowance allocation in order to gain political support.

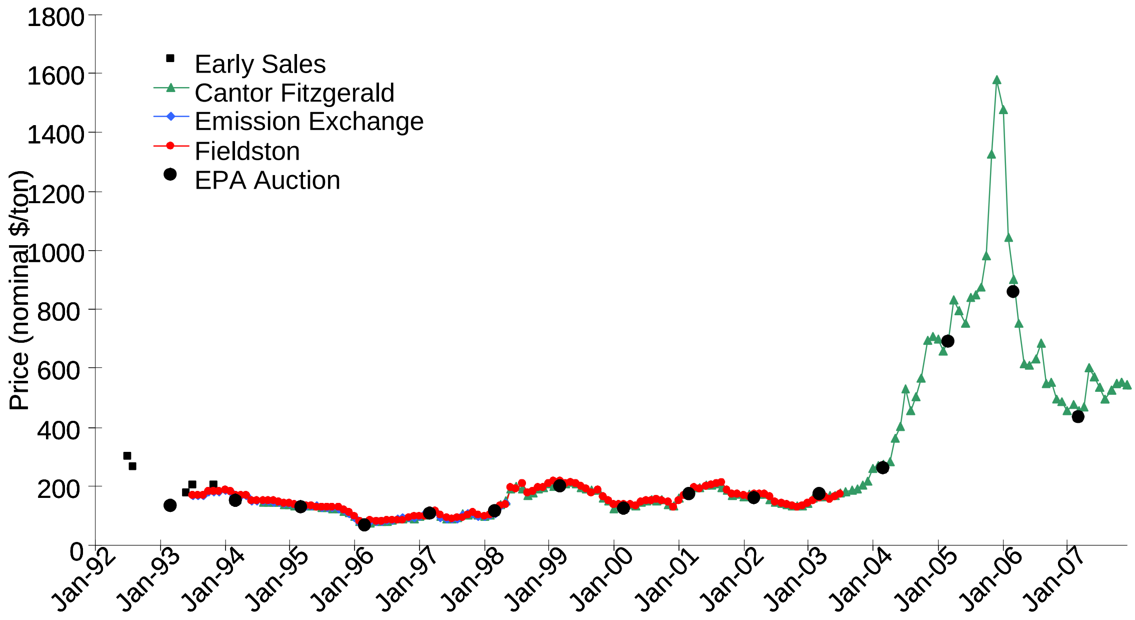

Figure 2.1 Evaluation of prices under USA's SO_2 trading scheme (Source: Denny Ellerman)

Phase I ran from 1995 to 1999, with Phase II beginning in 2000. The total cap was divided into allowances, each allowance being the equivalent of one ton of SO_2 emissions (Ellerman et al 2000). These allowances were distributed by US states to emitters proportional to their historic fuel input multiplied by a benchmark emissions rate. A small share of the allowances was retained and subsequently auctioned on an annual basis. Owners of allowances can use them to cover their emissions or trade the allowances. Trading gives emitters the flexibility choose between (i) reducing emissions to the volume of their allocation; (ii) reducing emissions below the volume of their allocation by investing in desulphurisation or closing down and selling excess allowances or banking them for future use under more stringent caps; or (iii) continuing to operate the installations at a high emissions level and buying allowances to cover the extra emissions from other market participants. As firms traded more actively and the government auction allowances, the market for SO_2 allowances became more liquid and the price more informative (figure 2.1). The flexibility together with a liquid market allowed firms to optimise across plants even where they are owned by different firms. Thus the least cost operation and investment choices can be pursued to comply with the emissions target.

An important component of the cap and trade scheme is monitoring, reporting and verification. At the end of a financial year each emitter has to surrender one SO_2 allowance for every ton of SO_2 emitted (Ellerman et al 2000). If the emitter does not surrender the necessary volume of SO_2 allowances there is a penalty of $3000 per excess allowance.[22]

The SO_2 cap and trade scheme in the USA is generally regarded as a success (Carlson et al. 2000). It created the political alliances that allowed for the implementation of the regulation. The flexibility offered by the cap and trade approach delivered the emissions reductions necessary to achieve the agreed targets.

There was a lively debate about the extent to which experience of the SO_2 trading scheme could be directly translated to CO_2 cap and trade schemes because there were some market differences between the schemes. The SO_2 cap and trade scheme was implemented against the background of pre-existing regulation, which ensured availability of emissions and technology data. Furthermore, the technology required for SO_2 emissions reductions was already widely used for new installations. This simplified the discussions on the SO_2 emissions caps, as it was clear that they could be achieved and it was possible to estimate the maximum cost industry would incur. The main objective of the scheme was therefore cost minimisation and securing political support for the implementation. As the value of SO_2 allowances is only a fraction of the value of carbon allowances, the unconditional allocation of allowances to emitters was politically less contentious.[23]

The positive feedback from the USA cap and trade programs, both for SO_2 and also for NO_x, was one of the starting points for implementation of the European Union Emissions Trading Scheme.

2.2 The European Union Emissions Trading Scheme (EU ETS)

Beginning in the 1990s the European Commission attempted to implement a European carbon tax. But industry opposition, German concerns that carbon taxes would benefit nuclear power, and the reluctance of some Member States to support a common European tax policy prevented progress of this policy. In response, the European Commission published a green paper on emissions trading in March 2000.

An additional push for a unified European approach to climate policy was the joint opposition of the EU Member States to the USA withdrawal from the Kyoto process. After senior politicians across Europe had criticised the USA behaviour they had to demonstrate domestic action themselves. European Member States had announced in the negotiations of the Kyoto protocol that they would deliver emissions reductions of 8% by 2008-2012.

By 2002 the increasing scepticism about the ability of governments to negotiate and enforce stringent voluntary agreements was confirmed. For example, there was increasing dissatisfaction with the level of ambition and enforcement of German voluntary agreements.[24] Also support for the UK emissions trading scheme declined. The UK government had negotiated intensity based and sometimes absolute emissions targets for individual sectors and firms and signed Climate Change Agreements. Companies could bid to reduce emissions beyond this base line, and then trade emissions reductions relative to the base line. However, it turned out that the stringency of the Climate Change Agreements was lax and the price for emissions reductions certificates fell below 6 €/tCO_2 (Smith and Swierzbinski 2007).[25]

The UK trading scheme and a similar approach in Denmark created the risk of a multitude of schemes that would not be consistent with the ideal of a common European market, which is the most important objective of European integration. This gave additional urgency to a harmonised European approach. In October 2003 the European Parliament and the Council of the European Union passed Directive 2003/87/EC, which required all EU Member States to implement a common cap and trade scheme by 2005.

Figure 2.2 illustrates the main features of the EU ETS. EU Member States have under the Kyoto protocol an overall emissions reduction target that was distributed among Member States in a subsequent Burden Sharing Agreement, which sets a total carbon budget to cover national carbon emissions. The EU ETS only covers 10,800 power and energy intensive industrial installations. Therefore each Member State has to decide what fraction of their budget they want to make available for these 'covered' sectors, and how much of the budget they retain for the emissions from transport and other domestic and industrial activities. This split is fixed and therefore the cap for the covered sectors is set before the trading period starts. At the same time the installations covered by the scheme, and therefore the demand is determined. Both are specified in National Allocation Plans that are proposed by Member States, approved by the European Commission, and then legislated by the national parliaments. Thus regulatory uncertainty is minimised that could otherwise result from later government intervention.

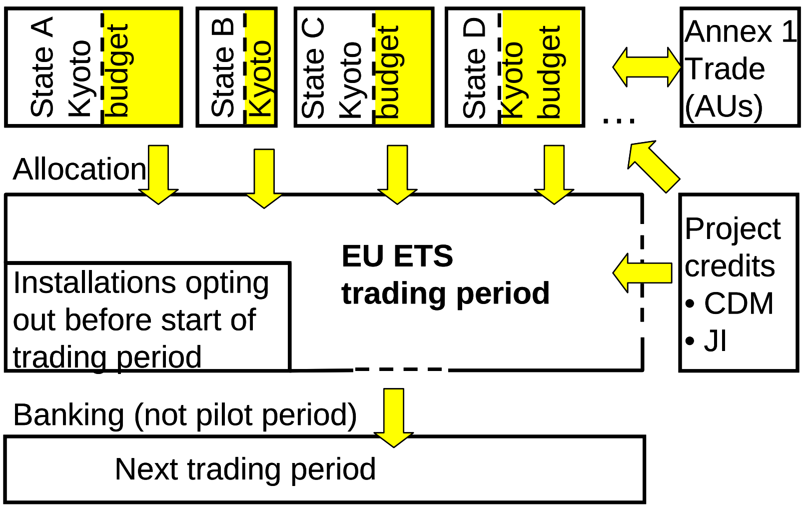

Figure 2.2 Structure of the European Union Emissions Trading Scheme

The EU ETS was designed to be able to function independently from the international context. This ensured that the scheme could be implemented even though the Kyoto protocol had not been ratified and was not in force at the time the Directive was passed. It also ensures the continuation of the scheme post-2012 irrespective of the international situation.

The Kyoto protocol allows for some emissions reductions in developing countries to be credited against emissions in developed countries. Therefore the 'linking' Directive allows firms to implement projects that reduce carbon emissions in other countries that signed the Kyoto protocol. The firms have to demonstrate that the projects deliver emissions reductions that would not be realised without the financial support from the carbon credits (additionality criterion). Separate processes apply to projects implemented in countries that have accepted binding targets under the Kyoto protocol, so called Joint Implementation projects (JI),[26] and to signatories to the Kyoto protocol that have no binding targets, so called Clean Development Mechanism projects (CDM).

To ensure that countries not only buy project credits to meet their emissions reduction targets, but also pursue policies to reduce their domestic emissions, the Kyoto protocol states that emissions reductions under JI and CDM have to be supplementary to domestic emissions reductions. This has been translated into EU legislation by limiting the amount of JI and CDM project credits each installation can use to cover its emissions. While the limits differ across countries, their European average is 13.4% (Tendances Carbone 2007).

Some developed countries that signed the Kyoto protocol, like Belarus, Ukraine and Russia, have emissions budgets, so called assigned units (AU) to cover their emissions, that far exceed their expected emissions in the period 2008-2012. This is a result of the unexpected emissions reductions from the economic downturn and subsequent economic transition of the former Soviet Union and associated countries. Under the Kyoto protocol the successor states are allowed to sell assigned units that are not required to cover domestic emissions (often labelled 'hot air') to other developed countries. Their use is controversial, because emissions have reduced due to non-climate related factors. Also, because their supply exceeds demand after the USA did not sign the Kyoto protocol, it is unclear whether their trade creates scarcity and thus incentives for emissions reductions in the selling countries (Grubb 2004). To insulate the EU ETS from uncertainties associated with AU trading, the direct use of such assigned units was not permitted in the scheme.

Two indirect channels for trade of assigned units to influence the volume of allowances in the EU ETS are illustrated in figure 2.2. First, Member States can buy assigned units and increase the share of allowances they devote to the cap and trade scheme in their National Allocation Plans. This is, however, only possible before the beginning of a trading periods, e.g. in 2007 for the period 2008-2012. Consequently, it does not create uncertainties during the operation of the scheme. Second, many Member States have invested in CDM and JI projects to obtain project credits to cover some of the emissions in the non-ETS sector. Member States can instead decide throughout the trading period to buy assigned units to cover these emissions, e.g. from Russia, and to sell their CDM and JI project credits to installations for use within the EU ETS scheme.

Finally, banking of allowances can influence the supply-demand balance within one trading period. Emitters, and more broadly, any party with an address in the EU that has registered to participate in the trading scheme, can bank an allowance for an unlimited period. It is expected that in the case of excess supply in the market, such banking will induce entities to save allowances and thus ensure continued scarcity of allowances and positive prices. However, as the first trading period (2005-2007) was designed as a pilot phase, banking of allowances from this period towards the second trading period (2008-2012) was not permitted in order to protect the integrity of the second trading period from potential difficulties in the pilot phase and to ensure that the volume of allowances in the second trading period do not exceed the Kyoto target.

2.3 Setting the cap – a simple recipe beats many cooks

We will now discuss in detail two aspects of EU ETS – first cap setting and then the allocation of allowances under the cap. In the European policy process both steps were closely linked. In the pilot Phase I Member States determined their National Allocation Plans specifying the emitters covered by the scheme and the volume of allowances allocated to individual emitters. The plans also determined the volume of allowances retained for new plants that will be commissioned during the trading period and the volume of allowances to be auctioned during the trading period. Thus the National Allocation Plans determined the volume of allowances issued by any one country, and the sum of all National Allocation Plans set the cap for EU ETS.

The balance between the overall cap and demand for these allowances by emitters covered by the scheme then determines the market price for allowances. If market participants set lenient caps, allowance prices are low. Stringent caps push up prices so as to induce additional measures to reduce emissions. Figure 2.3 shows the prices at which allowances for the pilot period 2005-2007 were traded. Already in 2005 forward contracts for allowances in the second phase of 2008-2012 were trading, and are depicted in parallel in the figure.

Throughout 2004 several Member States submitted National Allocation Plans with lenient caps. As a result the price at which forward contracts for allowances were traded in the grey market dropped to about 8 €/tCO2. The main reason for this over-allocation was that allowances were allocated for free. Such free allocation increases the opportunity and motivation for lobbying. Furthermore, governments had limited and inaccurate information on emissions of the level of emitters and on abatement opportunities of different industries.

In the pilot period 2005-2007 the European Commission did not have sufficient leverage to request extensive cuts to the volume of allowances issued and allocated by of Member States. The EU Directive on emissions trading only required “the total quantity of allowances allocated [to] … be consistent with assessments of actual and projected progress towards fulfilling the Member States' contributions to the Burden Sharing Agreement among EU Member States”. Member States argued that their overall national allocation plan for the period 2005-2007 was consistent with initially slow and subsequently rapid progress towards their 2008-2012 targets.

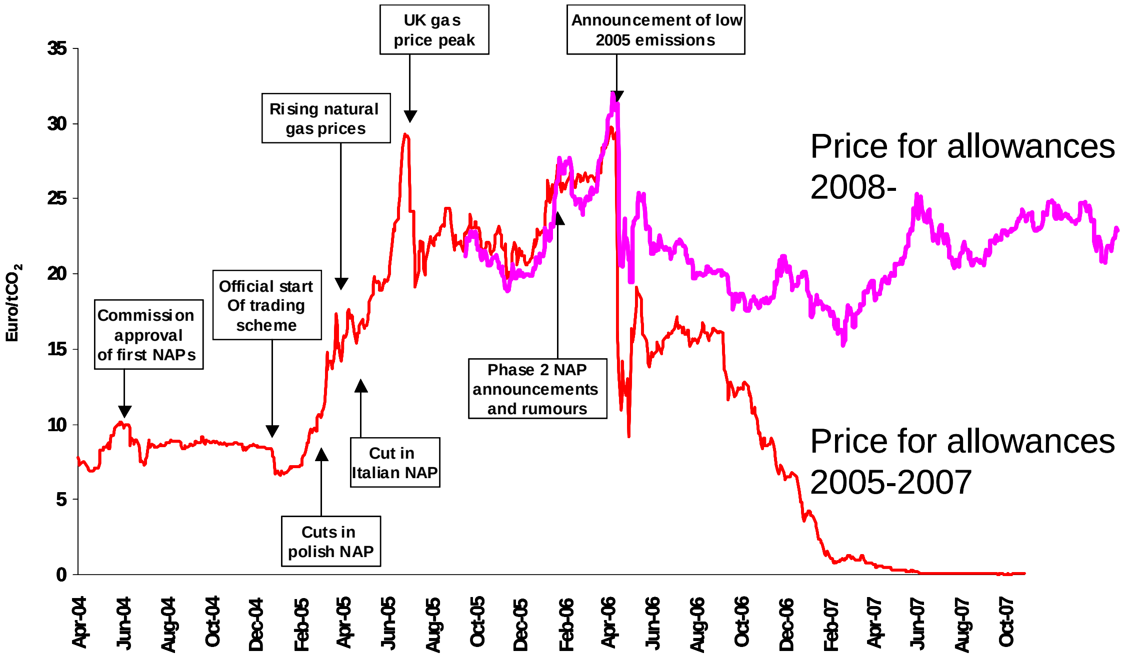

Figure 2.3 EU Emissions Allowance Prices: January 2005 to February 2008 in €/tCO_2 (European Energy Exchange 2008)

State aid rules were the main instrument the European Commission used to reduce the volume of allowances allocated by Member States, and thus the overall cap. If allocation provisions implied more allocation of allowances to installations than their expected emissions, this was deemed an unwarranted state subsidy. In a draft French plan and subsequently in the submitted Polish plan the European Commission requested a reduction of allowance allocation to individual emitters. The Commission also requested cuts to the caps in Italy, as the implied emissions level was far too lax relative to any reasonable trajectory towards the Kyoto commitment. While these examples did contribute to an increase of the allowance price in spring 2005, overall the Commission had little leverage on the National Allocation Plans of the pilot phase.

Fuel prices had a strong influence on the allowance price. In the first half of 2005 market participants anticipated that a shift from generation by coal power stations to gas power stations would be required to deliver emissions reductions. At the same time, natural gas prices increased. Thus the carbon price at which it is economical to replace production of coal power stations by gas power stations also increased. Hence market participants traded CO_2 allowances at higher prices.

As the natural gas prices continued to rise, the carbon prices required to switch would have exceeded 30 €/tCO_2, but at this stage market participants investigated what other abatement options were available. For example in the German power sector, a shift from lignite to hard coal generation was viable once allowance prices exceeded 20 €/tCO_2. Observing this mitigation option, traders anticipated what would suffice to deliver the reduction target, and the allowance price dropped to the corresponding level. Also the cold late winter in 2005 followed by a hot summer influenced perceptions, and there may have been a structural reason for the increase. Namely the power companies in the longer standing Member States were generally short of allowances and wanted to buy, but some of the industrial companies who were long were not interested in selling. This illustrates how uncertainties about the fundamental drivers for allowance prices resulted in creative explanations for price drivers and price volatility – typical signs of learning by market participants.

In April 2006 the publication of verified emissions data for 2005 triggered a massive price drop. The total volume of allowances allocated to emitters exceeded emissions in the year, confirming early concerns of a lack of scarcity due to allocation. In fact the verified emissions data was leaked a few days before its official publication, which created some profitable opportunities for some market participants with insider information, and resulted in a price drop before the official publication dates. This episode demonstrated that it is important for governments to carefully manage commercially sensitive data.

Despite the confirmation of the large surplus in the market by the verified emissions data, the allowance price stayed at 15 €/tCO_2. Various theories circulated, ranging from delays to the operation of registries in some EU countries, small emitters not selling surplus allowances, or financial institutions with an open position in the power markets buying allowances to support the carbon price and thus also the electric power price. But by December 2006, most of these perceptions seemed to have been disproved or vanished, and the allowance price had dropped to a few Euros. Thus the pilot period de facto ended in early 2007 because of over-allocation.

It is often argued that if banking between the pilot period and second period (2008-2012) had been permitted, prices would have been less volatile and would not have collapsed (Ellerman and Joskow 2008). This would have allowed traders to arbitrage away the price difference between first and second period. While the separate pilot period might have been crucial as part of the first ever application in Europe to protect the integrity of the scheme, future trading schemes might be able to learn lessons from the European experience with emissions trading without the need of an explicit pilot phase.

The pilot period delivered both important results and lessons. On the results side it delivered a working system of monitoring and verification of emissions, and a trading environment with all the necessary components. Measuring the results in terms of directly avoided emissions is difficult because 18 months of significant carbon prices is too short a sample period. In addition, peaking gas prices in this period would likely have resulted in additional emissions from coal power stations replacing gas in the counter-factual. Ellerman and Buchner (2007) estimate that between 2.5% and 5% of emissions were saved in the period 2005/2006 due to the EU ETS, but acknowledge large uncertainties in particular with regard to the counterfactual. The most important result of the pilot phase, however, was that the scheme alerted industrial and power companies to the issue of carbon prices. Nowadays carbon impacts are evaluated for all projects and are an inherent part of management decisions.

One important lesson from the pilot phase was the revelation of excess allocation of allowances, which can be attributed to four main factors: (i) poor data quality for historic emissions required for basis of the initial allocation; (ii) the intrinsic optimism of industry about production and thus emissions increases; (iii) flexibility granted to individual installations to exclude a year of low production from the base period; and (iv) insufficient attention given to the impact for other Member States.

All Member States were lobbied by their domestic industries to increase their allocation. Such additional allocation created no direct costs for a Member State, because there was no binding national cap for the pilot phase pre Kyoto, and therefore national governments did not have to compensate extra allocation to the trading sector with additional mitigation efforts in other sectors. The negative impact of more allowances issued in one country was a reduction of overall scarcity in the European allowance market below the politically desired level, which is unlikely to receive much attention in domestic decision processes.[27]

The experience of over allocation in the pilot phase threatened to be repeated when Member States developed their National Allocation Plans for phase two (2008-2012). A combination of imperfect data on availability at the beginning of the allocation process and continued strong lobbying pressure resulted in proposed National Allocation Plans that envisaged allocation volumes that were incompatible with the Kyoto commitment and with a scarce allowance price.

This time, however, the European Commission was in a stronger position to request changes to these plans for three reasons. First, the low allowances prices from Phase I demonstrated that cap and trade with lax caps cannot deliver scarcity prices. Second, climate change had moved up the political agenda and the European Commission had ensured that the administration received the necessary political support in negotiations with Member States. Third, the Kyoto targets provided clear criteria for the assessment of National Allocation Plans by the European Commission. The sum of allowances a Member State allocated to installations covered by EU ETS and the expected emissions from other sectors could not exceed the national targets.[28]

This formal and political power allowed the Commission on November 26th 2006 to establish clear quantitative criteria that National Allocation Plans had to satisfy. In its decision on the first 10 National Allocation Plans it required cuts of 63 million tonnes CO_2. It eventually reduced the allocation from 2348 MtCO_2 requested to 2103 MtCO_2, a reduction of 245 MtCO_2 representing a 10.3% cut in proposed allocations and a 5.7% reduction compared with 2005 verified emissions. Thus to give some examples:

	Proposed cap $MtCO_2$	Allowed cap $MtCO_2$
Germany	482.0	453.1
Greece	75.5	69.1
Slovakia	41.3	30.9
Sweden	25.2	22.8
UK	246.2	246.2

Various countries threatened to sue the Commission on the decision – in particular the opposition of the German industry ministry was of concern. Fortunately Germany was hosting both the G8 and EU presidency in the first half of 2007, and it would have been difficult for Germany to negotiate long-term climate policies while undermining the credibility of the European flagship policy instrument. Hence the government eventually accepted the decision of the Commission. Chapter 3 will return to the importance of robust implementation of policies against lobby interests of incumbent stake-holders, to create credibility of long-term ambitions in order to drive low-carbon investment decisions. Figure 2.3 illustrates that forward prices for the period 2008-2012 are trading around 25 €/tCO_2, which is in the range envisaged by policy makers. This suggests that the market confirms the analysis of the Commission.

The excessive allocation by Member States points to an intrinsic difficulty of decentralising the cap setting to Member States. Any state faces the incentive to increase the cap, to satisfy either demands for free allocation by domestic industry or bigger auction revenues by its treasury, while the costs in terms of insufficiently scarce allowance markets are shared by all Member States. Therefore the Directive that was proposed in January 2008 by the European Commission to improve aspects of the European ETS defines one common cap and a harmonised allocation methodology across Europe for installations receiving free allowances. But the majority of allowances are shared across the Member States so they can auction them.

2.4 Distributing allowances – compensate or distort

Economic textbooks usually state that the method of allocation does not affect the economic efficiency of cap and trade schemes because trading allows market participants to find the least cost emissions reduction opportunities. The implicit assumption is that the allocation is based on one, fixed, historic base line. USA cap and trade schemes for SO_2 and most of the NO_X programs followed this model. Allowances were typically allocated for more than a decade using historic production volumes; the allocation then remained fixed irrespective of subsequent operation, investment or even closure of the plant.

The EU ETS, however, is characterised by initially short allocation periods, of first three and then five years. Experience from these periods suggests that allocation decisions are based on recent information regarding individual emitters. Hence, the allocation of allowances is not, as in the text book, a one-off transfer. Instead, future allocations are contingent on today's operation, investment and closure decisions. Hence, owners of plants form expectations about how their current behaviour will influence future allocation decisions of governments. Expectation about future free allowance allocation can thus distort today's decisions. Repeated free allowance allocation can create perverse economic incentives that reduce the efficiency of the Emissions Trading Scheme.[29]

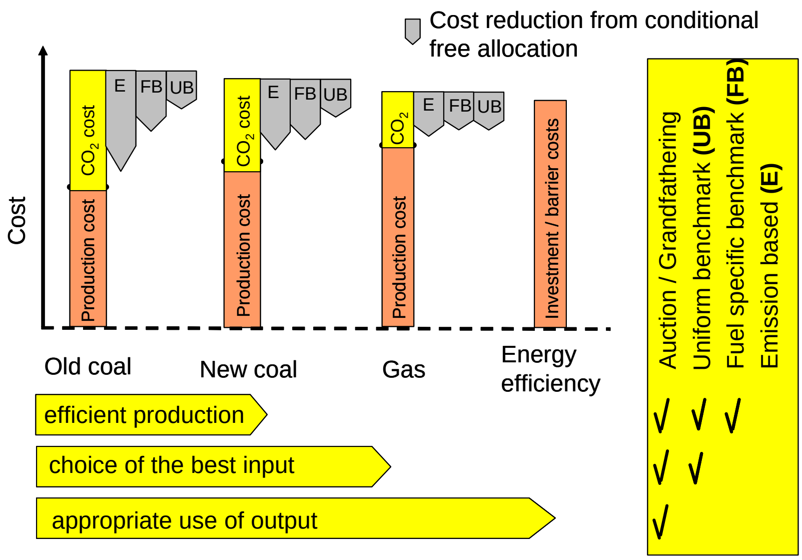

Figure 2.4 Illustration of distortions from free allowance allocation – example of the power sector

Figure 2.4 provides an illustration which is used in the following subsequent sections to illustrate some of the effects using a very simplified representation of the power sector. Starting from a situation without emissions trading, it illustrates that is cheaper to continue the operation of older coal power stations, than to build and operate a new and more efficient coal power station. At current gas prices, the cost of gas generated power is again higher. Overall, cheap power limits the interest of companies and consumers in pursuing energy efficiency measures.

The yellow bars adding carbon costs to production costs illustrate the purpose of emissions trading. The carbon costs are highest for old, inefficient, coal power stations while no carbon costs are incurred where energy efficiency measures are pursued. Thus carbon pricing creates incentives for a substitution to more efficient power stations, less carbon intensive fuels (e.g. gas) and energy efficiency. However, as will now be discussed, repeated free allowance allocation, reduces some or all of these incentives.

2.4.1 Distortions from grandfathering with a moving base line

Where allowances are grandfathered using a moving base line, the distortions from free allowance allocation to existing facilities are strongest.

Assume a chemical plant received free allowances for the period 2005-2007 to match the average annual emissions in the period 1998-2002, and the same allocation methodology was repeated in the allocation for the period 2008-2012 matching average annual emissions in the period 2000-2004. The managers of the plant will use the historic precedent as the best indicator for future allocation, and assume that allowance allocation for the period 2012-2020 will match average annual emissions in the five year period 2005-2009. Thus reducing emissions by one unit in 2009 will reduce free allocation by one fifth of a unit in each of the years 2013-2020. Assuming a constant allowance value of 25 €/tCO_2 and a discount rate of about 10%, the emissions reduction would imply a forgone future allocation of 18 €/tCO_2. Not withstanding a carbon price of 25 €/tCO_2 the plant operator will only implement emissions reductions up to a cost of 7 €/tCO_2.

This effect is illustrated in figure 2.4. Allocating allowances based on emissions that are measured in a moving base line reduces the incentives for efficiency improvement, fuel switching and substitution of carbon intensive products like electricity with energy efficiency. It is called the 'strong early action problem' – lowering emissions too early reduces future allocation. If the EU ETS continues to use a grandfathering approach with a moving base line, some emissions reductions could thus be postponed indefinitely.

2.4.2 Distortions from benchmark allocation with moving base line

Benchmarks offer an improved methodology of free allowance allocation. The volume of allowances is not linked to the actual emissions of a plant, but to the production of the plant. The production is then multiplied by a benchmark factor to determine the volume of free allowance allocation. For example the electricity production of a power station is measured in some base year, and then multiplied by the carbon emissions the best available power station produces per unit of electricity production to determine the volume of free allowance allocation. The benefit of this approach is that the operator of the power station has an incentive to improve the efficiency of the plant, and since this will not alter the volume of future allowance allocations the owner keeps the benefit from the sale of allowances.

The discussion of benchmarks is frequently confused, because benchmarks can be defined in various ways. First, the benchmark can either be directly applied to the output of a plant, or can be related to the maximum throughput (capacity) which is multiplied with an industry wide utilisation factor to determine the average output. Second, the measurement of the output or installed capacity can either be based on some historic base-line, or can be based on recent (possibly even current) data.

From the perspective of economic incentives a benchmark will not create any distortions if it is based on a fixed historic base line. In practice, however, the base period for a benchmark is likely to shift towards recent observations with each new determination of free allowance allocation. Sometimes it is argued that the reference time should be close to current production, but this creates incentives that can influence strategic and operational decisions of firms. Some of these incentives might be intended to shield specific commodities from the carbon price signal if this price signal is not imposed globally, but it seems difficult to avoid severe ‘unintended’ consequences of this approach.

Figure 2.4 illustrates the effect of output based benchmarks. If all generation technologies receive the same amount of free allowance allocation per unit of power generated (uniform benchmark), then their effective generation costs will all be reduced by the same margin. The ‘only’ inefficiency that appears in the theoretical model is the attenuation of the power price increases, which reduces the incentive to use electricity more efficiently.

In practice, the benchmarks for free allowance allocation are usually higher for coal than for gas plants, while renewable and nuclear plants do not receive any allocation – they are fuel specific. This methodology creates the biggest subsidies for the carbon intensive fuels and consequently reduces economic incentives for efficient fuel choices. Supporters of such fuel differentiated benchmarks argue that in their calculations the fuel specific benchmarks did not create any distortions. But such simulations are very sensitive to fuel price assumptions, and the supposedly well designed schemes have perverse results if oil, gas or coal prices differ from the assumptions made by proponents when modelling their implications.

In addition to these rather obvious distortions created by benchmarks, their use can have more subtle and possible even more serious implications. First, if the benchmarks succeed in shielding some sectors from the carbon price, then these sectors will continue to invest in high carbon assets and increase their emissions (Harrison and Radov 2002). This will push up the carbon price that is required to deliver overall emissions reductions, and increase the overall cost of climate policy. [30] Second, benchmarks that work effectively when used to collect data on industry performance and best practice, may be vulnerable to gaming by firms if they are used to allocate allowances valued at hundred of millions of Euros. To limit gaming, benchmarks have to be very narrowly defined and carefully administered, but this precision reduces the flexibility offered by a market based instrument and undermines the incentives for innovation in the production process and product specifications.[31] Third, the different allocation decisions that emerged across European countries in the first two phases of emissions trading suggest that definition and scope of benchmarks are driven by the political power of incumbent firms as much as by economic rationale. Free allowance allocation offers incumbent companies an opportunity to lobby for government intervention on their behalf, thus limiting the market opportunities and increasing the risk for new technologies and innovative companies.

2.4.3 Distortions from closure provisions

Closure provisions can create incentives to keep old and often inefficient plants operating that might otherwise be shut down and replaced. Most National Allocation Plans do not allow emitters to retain allowances beyond the period for which they are operating or operational.

This creates a financial benefit for continued existence and thus can delay closure decisions, which creates an economic cost as it results in a deviation from the least cost operation. Consequently, the cost to move to a low-carbon economy is increased and the overall competitiveness of the European economy is reduced.[32]

Although it would in theory be possible to avoid closure provisions in a National Allocation Plan, it is impossible for a government to make commitments about the specific allocation methodology for the next trading period. The allocation will result from the negotiations of the next allocation plan. It is difficult to envisage any government allocating allowances to the previous owners of a plant that no longer exists. First, handing out valuable public resources without any direct tangible benefit would be difficult to explain to the public. Second, the previous owners have little weight in the bargaining process, whereas other emitters can threaten closure with ensuing loss of jobs, innovation potential and future growth. Thus it is in practice not possible to commit that an installation that closes will continue to receive free allowances in the National Allocation Plan for the next trading period.

Where production is highly carbon-intensive and exposed to strong international competition, unilateral implementation of carbon pricing could result in re-location of production into areas with weaker, or no, carbon price signals. If such re-location results in the closure of plants, then the re-location could be delayed if closure provisions created incentives to encourage continued operation of plants. However, as these provisions will have to be closely linked to the production volume, they are likely to create similar distortions as discussed in the previous two sections in the context of output based allocation using historic emissions or benchmarks.

2.4.4 Distortions from new entrant allocation

All National Allocation Plans retain some allowances in what is called a 'new entrant reserve.' This probably creates one of the largest differences to previous SO_2 and NO_X cap and trade schemes. There are no such provisions in the USA SO_2 cap and trade schemes (Ellerman et al 2000). Under the NO_X budget programs states allocate allowances within their EPA-set budget. Again most states chose straight forward grandfathering for incumbents, while several states adopted updating, new entrant and closure provisions. Their distorting impact on investment and closure decisions is smaller, as their value per power plant is a fraction of the value of carbon emissions (Martin et al. 2007).

The initial justification for the free allocation to new emitters in the European scheme was threefold. First, to ensure a fair treatment of all emitters, new emitters also need to receive free allowance allocation. In the absence of a free allocation to new emitters it would have been difficult to justify the high levels of free allowance allocation to exiting facilities. Second, to avoid the risk that new emitters would not be able to buy sufficient amounts of allowances in the market, i.e. allocate to new entrants in order to postpone the need for auctions. If an auctioning system is not in operation, then new entrants would have to buy allowances from other emitters. It is possible these emitters exercise market power or do not engage in trade, thus constraining entry. Third, to compensate for some of the distortions resulting from closure provisions: as closure provisions create an incentive to retain old power stations in operation, new emitters also have to be subsidised in order to ensure firms replace inefficient old plants.

Although these are some tenable reasons to explain the role of new entrant reserves, they also create several concerns. As was already discussed in the section on benchmarks, fuel specific allocation can distort the investment and operation towards higher carbon technologies. Where benchmarks are applied in the power sector, only plants that use fossil fuels receive free allowances. Frequently the benchmarks differ between gas and coal. Figure 2.4b illustrates that coal stations often receive more free allowances than gas powered stations, and gas powered stations often receive more than non-fossil power stations. This distorts investment decisions towards carbon intensive fuel choices, which increases future carbon emissions. In Germany, Spain, Hungary, Italy, and the Netherlands coal generators received a much larger volume of free allowance allocation in the period 2008-12 than gas plants. Only the UK and Ireland provide the same allocation to both. These differences in allocation volumes incentivise new, carbon intensive plants in countries with more generous new entrant allocation. However, the European Commission has now proposed to auction all allowances to the power sector post-2012. This means that investments in 2008 or later will only gain from free allocation for at most a year or two, and therefore distortions from the new entrant allocation will in practice be limited.

Due to the exceptionally high level of subsidies under some proposed Phase II National Allocation Plans (NAPs), and the distorting effects of allocation decisions, the construction of coal power stations would have been more profitable under the EU ETS than without an emissions trading scheme[33]. The German NAP to the Commission was an extreme case. It not only provided the highest allocation for new coal generation in general, but the draft Allocation Law also contained a provision allowing an even higher free allocation for new lignite-fired installations. In addition, the proposed NAP suggested the continuation of free fuel-specific allocation for 14 years, which resulted in a surge of demand for coal power stations to be commissioned by 2012 and correspondingly high prices for contracts for the construction of the power stations, showing that new entrant allocation can increase costs of power generation. This policy would have undermined investment in low-carbon technologies, and meant that the plants would stay in the system for many decades, significantly increasing the cost of shifting towards a low-carbon economy in the future. The proposal was not accepted by the European Commission and subsequently several of the proposed new coal power stations have been cancelled. Distortion can arise both from the initial allocation to new plants, and from the expectations about the methodology of free allowance allocation in future allocation plans. In industrial sectors with highly differentiated production processes, as in chemical plants, there is also a risk that a benchmark will be tailored to a specific plant and thus de-facto constitutes emissions based allocation, which eliminates all incentives for efficiency technology choice.

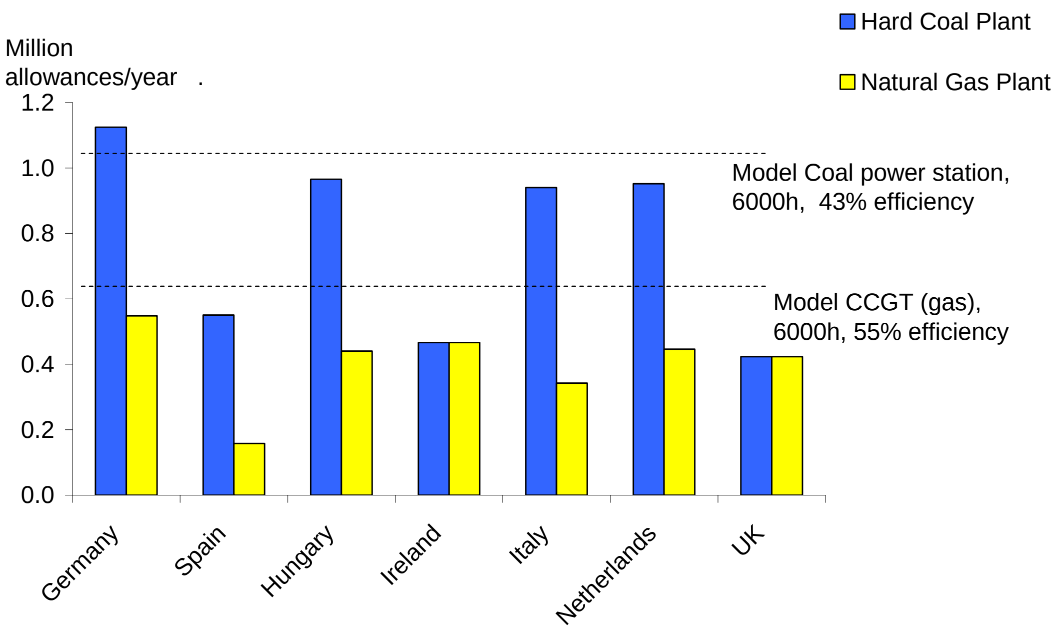

Figure 2.4b Comparison of new entrant allocation

The power sector industry lobby continues to use two mutually incompatible arguments in their attempt to receive continued free allowance allocation. Some utilities threatened that they would not build new power stations unless they were subsidised with free allowance allocation. Others argued that without free allowance allocation power prices would rise to reflect carbon costs and thus undermine the competitiveness of the European economy. If power prices rise to reflect carbon costs – as they already have in most European countries – then there is little reason for additional subsidies with free allowance allocation. In addition, if today's governments subsidise conventional power stations with ad-hoc free allowance allocation, then it is likely that future governments will do the same. But with ad-hoc subsidies it is impossible to predict the future power prices which determine the revenue streams of today's investments. Thus new entrant allocation undermines the basic principles of a liberalised power market and increases overall investment risk and costs.

2.4.5 Summary of distortions

We can summarise the distortions described above in the following pyramid of distortions. It illustrates that moving up the pyramid eliminates some of the distortions.

It is important to note that for the European ETS National Allocation Plans committing to free allowance allocation for the period 2008-2012 do not create major distortions once they were implemented in law in 2007. The fixed free allocation does not create an early action problem. There are two notable exceptions of the remaining distortions. First, closure provisions create incentives to keep emitting installations operational until 2012. Second, new entrant allocations distort incentives for investment decisions. However, as most capital intensive investment that is currently being decided will only be operational for the last one or two years of the period 2008-2012, these distortions are likely to be small. Hence the main distortions from National Allocation Plans relate to their influence on expectations about the allocation methodology to be used post-2012.

Allowance allocation method	*Impacts*	**More expenditure on extending plant life relative to new build**		**Increase plant operation**		**Less energy efficiency investment**
	Distortions	**Discourage plant closure**	**Distortion biased towards higher emitting plants**	**Shields output (and consumption) from average carbon cost**	**Distortion biased towards higher emitting plants**	**Reduce incentives for energy efficiency investments**
Auction						
Bench-marking	**capacity only**	X				
	capacity by fuel/ plant type*	X	X			
Updating from previous periods'	**output only**	Y		X		
	output by fuel/ plant type*	X	X	X	X	
	emissions	X	X	X	X	X

Note: X indicates a direct distortion arising from the allocation rule. Y indicates indirect distortions if allocation is not purely proportional to output/emissions.
* Differentiating by plant type adds additional distortions compared to purely fuel-based.

Figure 2.5 Pyramid of distortions of EU ETS, Source: (Neuhoff et al 2006).

In contrast to this, expectations about the allocation and price levels post-2012 continue to influence investment and operational decisions. Thus more certainty on these allocations is necessary to increase the efficiency of the EU ETS. As illustrated above, even with a shift to auctioning capacity related benchmarks post-2012, significant distortions for investment and closure decisions remain. Only a commitment to no free allocation post-2012 can eliminate all distortions.

As the cost of buying CO_2 allowances can to a large extent be passed on to consumers, it is difficult to justify continued free allowance allocation. As the experience of the first two trading periods illustrates, some initial free allocation is politically convenient to gain industry support, and might also be justified in terms of compensating industry for loss of value of high carbon assets in a low-carbon world. Nonetheless, a fundamental difficulty of such compensation is that it implies governments should cover losses that a firm incurs if it fails to make the right strategic decisions. The first report of the Intergovernmental Panel on Climate Change was published on behalf of all major governments in 1992, and outlined the threats from climate change. Subsequent reports, and international negotiations, have underlined the validity of the analysis. Most of the assets that will be ‘compensated’ with free allocation are either fully depreciated or have only subsequently been built or acquired by their current owner. The free allowance allocation will therefore reward managers for their failure to anticipate carbon policy despite publicly available information on the topic.

No one would consider compensating an oil company for an oil field that produces less oil than expected or a shoe producer if the trends of fashion change. Such compensation would create the wrong incentives for management and the wrong selection criteria for managers and successful companies. This suggests that trading schemes should also avoid compensating companies for losses in assets that forward looking management could have anticipated and prevented with appropriate investment choices. There is a long history of government regulation to address environmental concerns, and thus it was clear since the early 1990th that government regulation will be required to reduce anthropogenic greenhouse gas emissions. This shows that political economy drivers to compensate inefficient carbon-intensive industries in order to gain their support have to be balanced with economic incentive schemes that reward innovative and forward thinking companies and managers so as to deliver both environmental and wider economic objectives.

The only argument that remains in use to argue for and justify the possible continued use of free allowance allocation relates to international competitiveness and leakage. As it is currently not clear to what extent other countries will implement stringent carbon pricing schemes that expose producers to the full environmental costs from their emissions, there is a concern that carbon intensive producers might relocate their production. Chapter 5 will explore the concerns in more detail, and argues that for a very limited set of installations the option to allocate allowances for free post-2012 should be retained for this case, and be explored in international discussions together with other instruments that can be used to address leakage concerns.

2.4.6 Auctions

The European Commission package of January 2008 proposes to use auctions as the main allocation mechanism. This is a significant shift from the first two phases over which the Directive on emissions trading limited the role of auctioning to 5% and 10% respectively. In the Phase II, only Germany (9%), the UK (7%) and the Netherlands (4%) and Lithuania (3%) reserved significant volumes of allowances for an auction, with Hungary, Austria, Ireland and Belgium envisaging to auction less than 3% of allowances.

German government introduced auctioning in its revised National Allocation Plan in 2007 largely in response to a public debate about the windfall profits utilities made under free allowance allocation. The change in Germany was too late for revisions in several Nordic countries, where initial ambitions for auctioning where hampered by the negative attitude in Germany.

If allowances are no longer allocated for free, governments can either directly sell allowances to individual market participants or auction them. Direct sales are less transparent, creating the risk of market uncertainty and politically guided allocation. Thus auctions have become the preferred approach to create a clear and transparent interface between government and the private sector. The use of government auctions has developed a strong track record in government procurement and in sales of government bonds. The auctions of mobile phone licences have received significant public attention. Auctions are run in many economic sectors, notably in gas and electricity markets on a daily or hourly basis.[34]

The question which has to be answered at the outset of any auction design is: what are the objectives of the auction? In the European context five main objectives are discussed. First, simplicity and transparency can simplify communication, participation and acceptance of the auction and the overall Emissions Trading Scheme. Second, low transaction costs, moderate information requirements, cash flow implications, and low price risk will facilitate wide participation, including by small players. Third, the market clearing price in the auction should reflect the value of allowances in the market. Fourth, the design should minimise the problems arising from collusion and abuse of market dominance or market power; and, fifth, the design should help to maintain a liquid secondary market for emissions allowances.

Two criteria that are applied in other auction contexts are less likely to be core objectives in the case of CO_2 allowance auctions. Revenue maximisation should not be pursued in this case on the back of small emitters or players for whom trading is not a core activity, because these players are less informed and consequently will be disadvantaged. Efficiency of auctions relates to the question of whether the players who value the auctioned good at the higher price will buy the good in the auction. As carbon allowances are freely traded in secondary markets, it is not of concern in this case.

The discussions in the UK and the wider European context suggest that the main objectives for an auction design are compatible with each other, thus avoiding difficult trade-offs and negotiations with stake-holders who have different interests. A very simple uniform price auction design can achieve all the objectives required. Such an auction could be repeated on a weekly, monthly or quarterly basis, which limits the credit and cash requirements for auction participants and avoids the risk that a buyer who acquires all allowances in an auction can subsequently dominate the market. If concerns remain, then provisions from government bond auctions can be replicated that limit the maximum share of allowances that can be bought by one auction participant and its affiliates.

A remaining question for the auction design in Europe, North America and Australia is what share of the allowances should be sold in forward auctions? For example power companies sell electricity in forward contracts several years ahead of time, and then also sign contracts to cover their fuel purchases in the same time frame. If power companies anticipate receiving allowances for free, such hedging is not required. If the fraction of allowances allocated for free does not cover the forward power sales, then ‘forward auctions’ for allowances covering this volume of forward sales must be discussed.

It will be interesting to observe how the principles of auction design will be reflected at the level of detailed implementation. For example in the UK initially a group lead by the environment ministry with industry stakeholders developed a shared perspective and recommendations for the objectives and implementation of the auction. The Debt Management Office was then entrusted with a proposal for the detailed implementation. A subsequently published consultation document proposes to limit access to the competitive auction to selected intermediaries, most likely large banks (DEFRA 2007). This allows the Debt Management Office to pass the responsibility for money laundering checks to these intermediaries and replicates a model already applied for bond auctions in the UK. As such it might be a viable solution to the money laundering requirement. It is, however, not clear how an auction design involving intermediaries impacts open access, simplicity and transparency, in particularly, if other European countries follow this approach. This illustrates how important it can be to develop a shared understanding and sense of ownership and responsibility for the overall Emissions Trading Scheme across all government departments and countries.

The Regional Green House Gas Initiative (RGGI) covering emissions in 10 east cost states of the USA from January 2009 is planning to hold the first advance auction for allowances in September 2008. Four of the states are ready for the first event and will use a common auctioning platform. The expectation is that the other states will join this platform in the subsequent quarterly auctions. It is encouraging to see how careful implementation can deliver de-facto harmonisation and an efficient design. Hopefully close international cooperation on market design questions will continue to allow all countries to benefit from such experiences in other regions.

2.5 Conclusion

Carbon taxes and cap and trade mechanisms are two instruments that are in principle well suited to price carbon. As the methodology of taxation is generally well known, the discussion in this section was guided by the experience from cap and trade schemes. They have been successfully implemented across countries and US states for CO_2, SO_2 or NO_x. They offer the opportunity to integrate the environmental regulation across several jurisdictions, and for example impose a common carbon price across EU Member States.

The European experience points to the importance of clearly separating the cap setting from the allocation to individual emitters. This simplifies the process of choosing an appropriate cap that reflects emissions reduction objectives and economy wide mitigation opportunities. Initial free allocation of some allowances is frequently implemented to gain industry support and compensate for value loss of high carbon assets in a low-carbon world.[35] If free allocation turns into a repeated feature, then the expectations of market participants about future free allocation will distort the carbon price signal. This results in inefficient operation and investment choices.

In an existing scheme it is important to phase out free allowance allocation and move to auctioning of allowances. With careful design cap and trade can thus be a viable means to deliver a carbon price signal. An emission trading scheme where all allowances are auctioned creates similar revenue streams as a carbon tax. However, the political economy of the initial implementation of both instruments and the coordination of the price level across jurisdictions remain important differences. Also the determination of the carbon price differs between both approaches. The carbon tax is set in a political process and can be revisited annually. The carbon price in an emission trading scheme follows from a political decision on the cap, linkages and offsets of a trading scheme that is often fixed for many years at a time. The next section discusses the implications of the different price formation processes for investment decisions.

3 Carbon pricing to guide investment

Key messages:

Strategic and technology choices require a credible mid-term reduction target.
- *Appropriate carbon price creates market opportunities for low carbon choices.*
- *Cap and trade ensures carbon price responds to fuel & technology uncertainty.*

Project investment and finance is hindered by the risk of low carbon prices.
- *Reserve price in auctions and government issued put options address this risk.*

Credibility of scheme flows from consistency of short-term and long-term policies.
- *Joined-up thinking on carbon pricing, technology policy and regulation.*
- *Designing low-carbon transition requires participation from all sectors.*

Most carbon emissions reductions are expected from investment and re-investment choices in transport, housing and industry. Hence a main purpose of the carbon price signal is to drive investment choices. These choices, especially in infrastructure, are typically associated with long time frames, over which returns are expected to finance the initial investment. This does not automatically imply, as frequently argued, that infrastructure and technology choice cannot evolve rapidly.

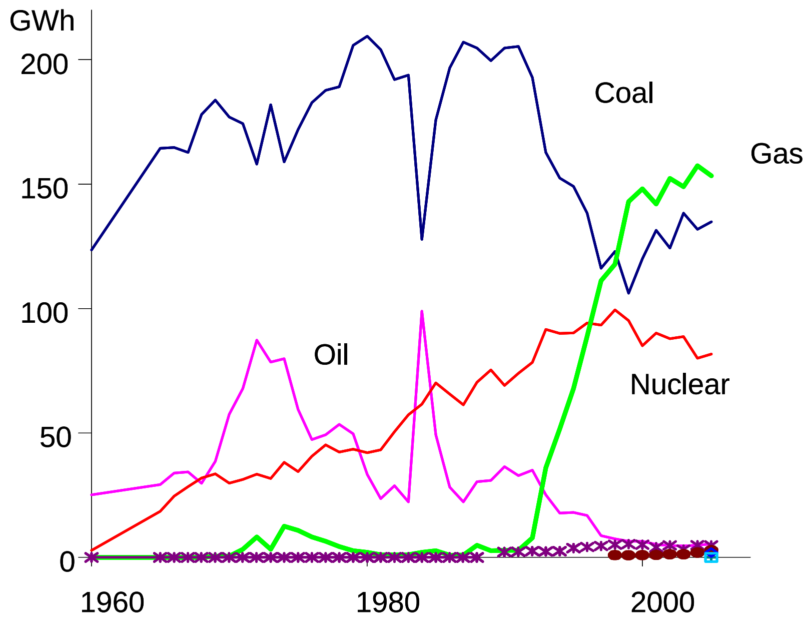

Figure 3.1 Generation share of different technologies in the UK (BERR): 1960-1997 Fuel consumption for power generation, transformed to output using 1998 average efficiencies,)

Figure 3.1 illustrates the rapid investment in Combined Cycle Gas Turbines for power generation which occurred after the liberalisation of UK gas and electricity markets in the early 1990s. Within half a decade the new technology captured the biggest market share of UK power generation. This illustrates that market environments can drive rapid change if the appropriate framework creates sufficient certainty for investors.

The European Union Emissions Trading Scheme has put carbon prices clearly on the agenda with executives of emitting companies. The cost of carbon is relevant to the investment decisions of 73% of energy intensive industries in Europe.[36] However, investors do not always perceive a robust investment framework for low carbon projects. The Stern Review (2006) on the economics of climate change highlights shared concerns about the impact of uncertain carbon prices on low-carbon investment choices:

> *In order to influence behaviour and investment decisions, investors and consumers must believe that the carbon price will be maintained into the future. [….] If there is a lack of confidence that climate change policies will persist, then businesses may not factor a carbon price into their decision-making. But establishing credibility takes time. [..] In this transitional period, while the credibility of policy is still being established and the international framework is taking shape, it is critical that governments consider how to avoid the risks of locking into a high-carbon infrastructure, including considering whether any additional measures may be justified to reduce the risks.*

3.1 The nature of uncertainty

Dealing with market uncertainty is nothing new for investors in energy-related markets. The impact of the additional uncertainty relating to carbon prices and allocation methodologies may at first appear to be limited. There are, however, two aspects that exacerbate uncertainty:

First, cap and trade and other climate policies are subject to regulatory uncertainty regarding the level of stringency, and under what rules carbon markets and other policy instruments are implemented. By its very nature, regulatory uncertainty is driven by soft factors relating to future decisions of policy makers. These are difficult to quantify, and therefore it is difficult to attribute probabilities to different future scenarios to include in analytic models used for investment analysis.

In addition to the national regulatory uncertainty, climate policy has international objectives and involves activities by many nations. The evolution of political processes that involve many actors and countries is particularly difficult to predict as frequently multiple outcomes are possible. If climate policy is implemented in only one part of the world, then this could accelerate technology development in that region, but concerns about leakage could also trigger inefficient policy responses. . Again, these distortions are difficult to quantify and predict (Smeers 2007).

Second, where a trading framework has been clearly established, for example, within the EU ETS after the National Allocation Plans have been decided upon, price formation is subject to market forces. They reflect uncertainties about technologies, demand and availability of input factors. While price uncertainty is typical of many markets, carbon price uncertainty has some special features.

There are no natural lower bounds for carbon prices or expectations of reversion to the mean in the long-term. This is in contrast to most commodities where marginal production costs set natural price floors. Also, the lack of a long price history implies that it is impossible to extrapolate future prices based on past experience, which are used in other markets to inform management and financing decisions. Finally, there is not even the historic data on supply and demand balances, which was available for markets created with liberalisation, like electricity, and allowed for approximation of historic performance.

The different aspects of regulatory risk for carbon prices and the particularly strong market uncertainties in the case of cap and trade schemes have received increased attention from analysts and policy makers, and have in some cases re-opened the debate whether cap and trade or carbon taxes are a more suitable policy instrument (section 3.2). It may not be possible to generalise the solutions, as section 3.3 illustrates how investment and financing approaches can differ across sectors. Section 3.4 discusses how the needs of investors with long-term perspectives can be addressed, while section 3.5 looks at policy instruments to support investment decisions by players with shorter-term perspectives.

3.2 Response to uncertainty with taxes and cap and trade schemes

Both climate impacts and mitigation opportunities are uncertain. This has implications for the choice of policy instruments.[37] Focusing only on the direct economic impacts, and ignoring aspects of political economy, while both taxes and cap and trade schemes deliver the same outcome in the absence of uncertainty, their performance differs significantly under uncertainty.

The economic debate about cap and trade versus taxation dates back to a paper by Martin Weitzman (1974). His analysis concluded that if the cost of reducing an additional unit of carbon emissions is independent of the emissions level while damage caused by emissions grows drastically with the emissions level, then cap and trade is the preferred policy instrument under uncertainty.[38] In contrast, if the cost of reducing carbon emissions increase drastically with the mitigation effort and the damage caused by a unit of carbon emissions is independent of the emissions level, then taxation is the preferred policy instrument under uncertainty.

Which of these scenarios describes the situation of climate change better? Looking at time frames might explain the different perceptions, as is illustrated in text box two. In the short-term taxation is the preferred policy instrument, while in the long-term cap and trade is more suitable. These two policy choices are, however, inconsistent. A long-term quantity announcement will only be credible if it will be enforced in the future. This suggests that policy makers have to use a policy instrument today if they want investors to believe that they will also use it in the future.

If policy makers choose a quantity based cap and trade approach, then this can facilitate long-term investment decisions. The future carbon price will respond to new information about costs of technologies and fuels, and ensure appropriate remuneration of low-carbon strategies and investments.

If policy makers choose a price based approach, like taxation, then the stable price signal can support shorter-term investment choices. However, it is not yet clear what carbon price level will be required to make certain technology options of fuel choices economically viable for firms. Therefore the use of carbon taxes means, inherent uncertainties about long-term mitigation costs translate into uncertainties about future emissions levels, which creates another credibility issue. Investors will only have confidence in a policy instrument that delivers against policy objectives. Otherwise investors suspect policy makers might change the instrument, and they will wait until the changes have been implemented to provide resources.

Hoel and Karp (2001) and Newell and Pizer (2003) were the first in a long-list of authors to model the relative merits of taxes and emissions caps. They conclude that with uncertainty taxes are preferred to quotas. This is, because with unexpected economic and emissions growth the carbon price would rapidly increases imposing high costs on their model economy. However, they assume technologies are exogenously given rather than emerge with private sector investment and thus limit the flexibility of an economy to adjust its carbon intensity.

To discuss these policy choices in more detail, we need to move from the perspective of ‘general’ investment decisions to a better understanding of the impacts on individual investment choices in different sectors.

Text box 2: Tax versus Cap and Trade

Figure 3.2 uses the Weitzman framework to assess whether policy makers should set prices (taxes) or quantities (emissions trading). It shows that costs of additional mitigation efforts increase with higher levels of mitigation. At the same time, the damage from an extra ton of CO_2 in the atmosphere is likely to be lower if high levels of mitigation result in lower concentrations of CO_2 in the atmosphere.

In a world without uncertainty the carbon tax level can be set at the price of the intercept of mitigation costs and damage – and the optimal level of mitigation is implemented. Also the cap of an emissions trading scheme could be set to match the optimal level of emissions reduction. Thus in this very simple world without uncertainty both schemes can deliver the same result.

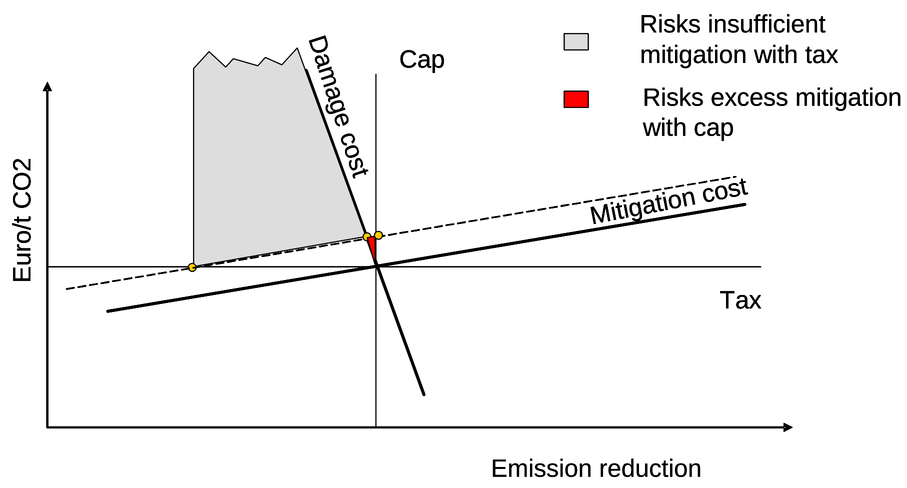

Figure 3.2 Marginal damage and mitigation costs – and the impact of uncertainty

With uncertainty the mitigation costs could be higher than anticipated (dashed line in figure 3.2). The new optimal price and quantity of mitigation is given by the intercept between the dashed mitigation cost curve and the damage cost curve. But this optimal point cannot be reached because governments had to choose and implement a policy instrument before all information is available.

If the government decided to implement emissions trading and sets a cap, then the market result will be determined by the intercept of the cap with the mitigation cost curve. With unexpectedly high emissions costs, the emissions trading scheme will result in greater mitigation efforts than would be optimal. The red area in the graph illustrates the emissions reduction measures that are pursued even though they are more expensive than the marginal damage that is avoided from the emissions reductions they create.

If alternatively the government decided to implement carbon taxes, then the new market result will be determined by the intercept of the dashed mitigation cost curve with the tax level. In this case less emissions reductions will be implemented than optimal. The grey area in the graph illustrates the damage caused by these extra emissions beyond the cost of mitigation that would have avoided the damage.

Comparing both policy instruments we find that in figure 3.2 the welfare losses from underestimating the mitigation costs are higher if taxes are used than if emissions trading is used. The result can be generalised. If the mitigation cost curve is flat relative to the damage cost curve,

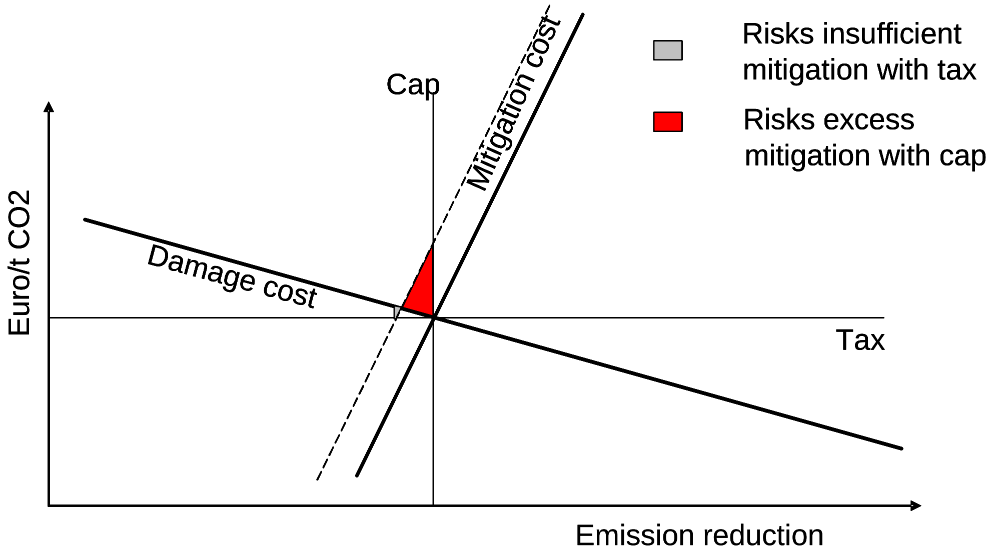

Figure 3.3 Marginal damage and mitigation costs – and impact of uncertainty

One would expect that empirical evidence could be used to answer the question of whether mitigation or damage cost curves are steeper – but good data, including on elasticities, is scarce and opinions still differ.

Regarding the damage cost curve, some modellers argue that temperatures increase logarithmically with the level of atmospheric CO_2 concentrations, and damages increase exponentially with temperatures. This would imply that damage is a linear function of CO_2 concentration and the marginal damage cost curve is flat (similar to figure 3.3). This would be one argument for the use of carbon taxes set at the level of marginal damage (Hope and Newbery 2008). The question is how to calculate this damage (Tol 2003). Economists still discuss the appropriate discounting and risk factors (Guo et al. 2006), scientists discuss the impact on different countries, and few people dare to put cost figures to impacts like large scale droughts inducing starvation and migration.

The confidence in predictions and quantification of climate change impacts outside of the ranges experienced by our societies is still limited. In national and international policy discussions the aim is thus to define a temperature increase that our societies do not want to exceed as the impact would be perceived to be unmanageable (Stern Review 2006). According to the latest IPCC report, the median expected global temperature increase is in the order of 2-2.4°C, if CO_2 concentrations exceed 490ppm. To give some confidence that temperature will stabilise at this level, global CO_2 emissions have to be reduced to 50% of the current level. From this overarching objective the permissible emissions levels can be deduced and emissions targets can be set. This approach has an implicit assumption that damages increase disproportionally once the threshold is crossed, reflecting the risk of large scale disasters. The steep damage cost curve suggests a need for the use of targets and caps.

Perspectives not only differ on whether damage costs curves are steep or flat, but there are similar discussions about the shape of mitigation cost curves. Many mitigation opportunities require new investment or refurbishment of existing buildings and infrastructure. This takes time and implies that in the very-short term the mitigation potential is limited, and thus the mitigation cost curves are steep. As the available time frame increases, the set of possible mitigation options expands and the mitigation cost curve becomes flatter. Some studies, see for example figure 1.2, predict for the long term (e.g. 2030), a flat mitigation cost curve across various measures that are available once the initial cheap options are realised. Whether the mitigation cost curve is really that flat depends on the assumptions one makes on uncertainties in predicting costs of technologies like CCS and renewables and on fuel prices.

3.3 Investment under uncertainty – contrasting different sectors

Companies across sectors differ in their response to the uncertainty for historic, institutional and technological reasons. Based on interviews with managers and analysts across these sectors, this section offers straw-man representations of the main drivers for strategic decisions and project choices. The simplification inherent in such a representation implies that all the differences that exist within sectors between companies are ignored even though they might be larger than the differences between sectors. But sector names allow for an easy identification of perspectives, and hence the focus is on oil majors, technology companies, utilities, banks and project developers.

Oil majors undertake investments with long horizons against internally developed scenarios of the global market and geopolitical evolution. The stringency of current climate policies is an important political signal, as they are an indicator for the credibility of future targets. Oil majors infer from long-term targets and perspectives the role of different technologies or the implied long-term carbon price. Investment projects are then benchmarked against projects from other business. Projects are also assessed against possible projects pursued by competing companies in order to identify competitive advantages and anticipate profitability.

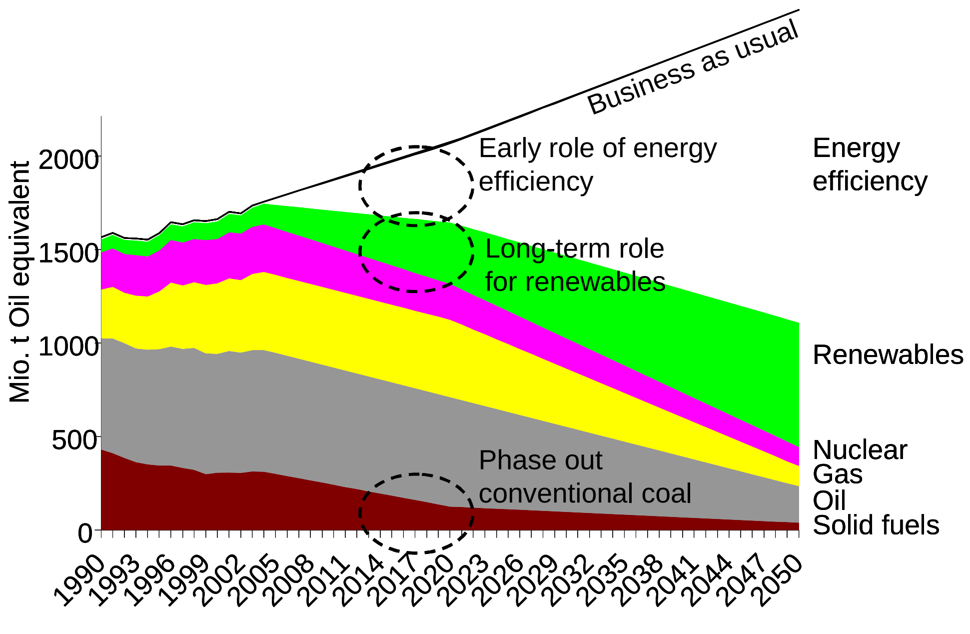

Figure 3.4 Using long-term emissions targets to assess the roles of different technologies over the next four decades (example EU-25).[39]

Current spot and forward prices for oil and carbon are less important for the long-term investment decisions of oil majors, and more relevant for risk and uncertainty analysis to determine and manage shorter-term exposure to upside and downside risks. In the initial years carbon prices are unlikely to have a strong impact on oil demand due to inelastic demand and already high taxes. Transport sector specific policies are likely to be more relevant.

Technology developers and manufacturers are always eager to move their new technologies forward. Yet, to obtain funding they have to show credible scenarios for the role of their technology to third parties. They cannot use the approach of oil-majors to deduce the future market share of their technology from future emissions targets because (i) internally developed scenarios illustrating the role of a certain technology are not credible to convince third parties to provide financing, and (ii) many pathways lead to long-term emissions targets. Between the various pathways the time when individual technologies start to make significant contributions to the energy mix will vary significantly. This complicates planning and creates additional risk for technology investors who typically do not have the financial endurance to wait for markets to evolve. The results from the real-options simulations show that adoption of new technologies depends significantly on investors' view of uncertainty (Reedman et al. 2006). Figure 3.5 illustrates that explicit renewables targets, e.g. for 2020, can provide reassurance that policies will be in place to address technical and administrative barriers for the deployment of renewables. They can contribute to confidence that there will be a market for successful technologies in the time frame required by investors.

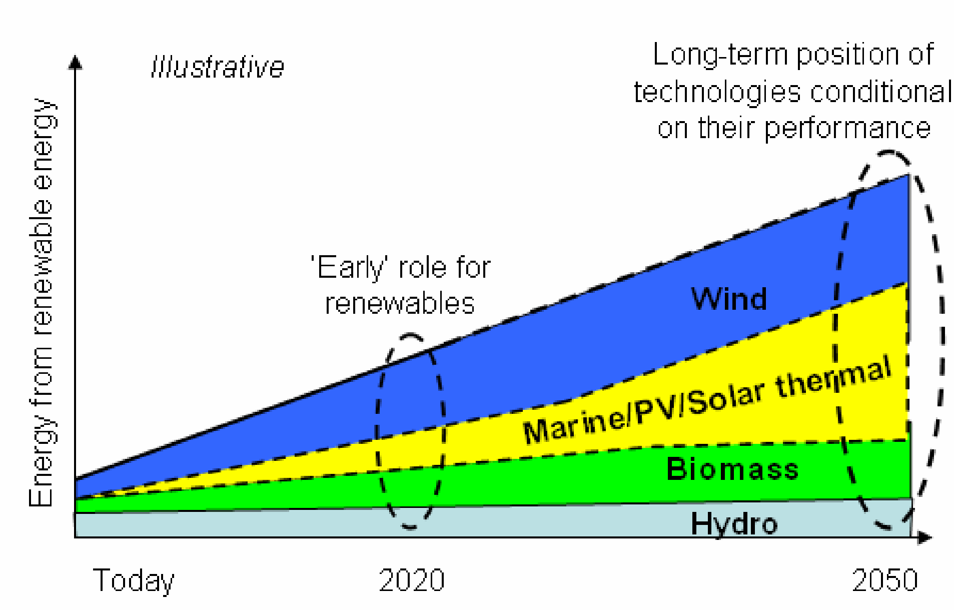

Figure 3.5 Use of renewables targets to assess role different renewable technologies can play in portfolio.

Utility companies have long experience of how regulatory and policy choices determine investment outcomes. The differing market shares of nuclear energy across countries illustrate that such policy preferences are difficult to explain using simple economic reasoning. Utilities are therefore mainly guided by current policy frameworks, like ETS, when assessing investment choices (Reinaud 2003). Current prices, forward prices, and existing policies are dominant drivers for investment choices and only credible commitments to changes of these policies will affect decisions.[40] In the absence of any such strong guidance, some utility companies might continue with traditional investment approaches, mainly focusing on diversification between coal and gas.[41] This is particularly the case where stated policy goals are not aligned – like reducing import dependency by using more domestic coal and reducing emissions by importing more gas.

Banks provide debt to finance investments across different sectors. They have to implement internal control mechanisms to ensure individual business units do not take excessive risks, and are reluctant to engage in speculation about future evolution of markets and policies. Rather they prefer to use data on historic performance of technologies and sectors to assess investment risks. In the absence of historic data they accept policies if they are sufficiently simple, transparent and credible.

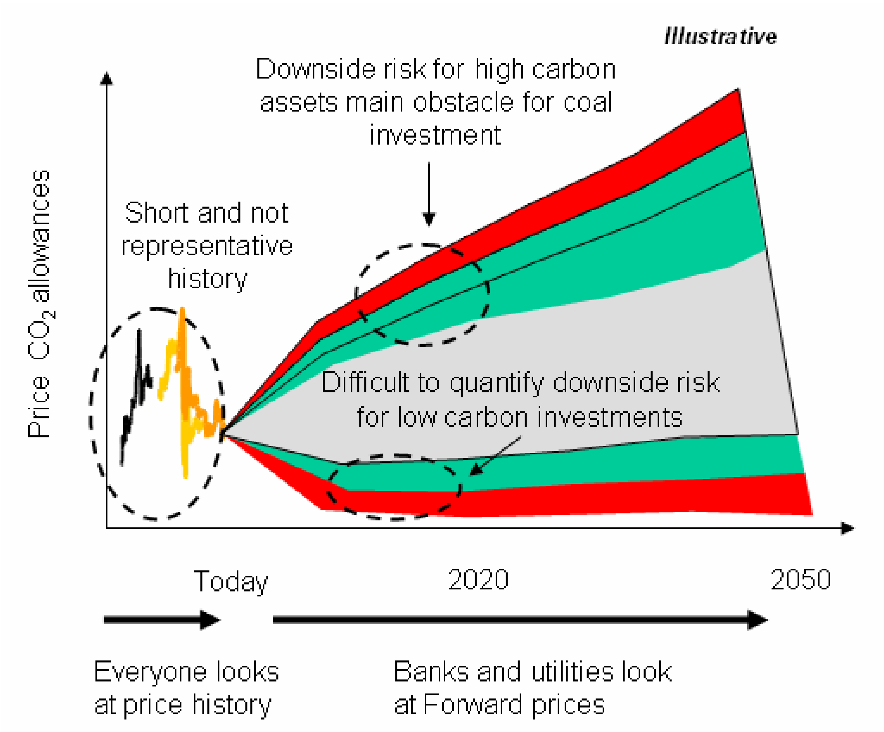

Figure 3.6 Impact of carbon price projections for agents involved in investment decisions

Table 3.1 summarises the inputs which drive investment and strategy choices in different sectors. Oil majors and technology companies have a strong focus on the possible future role of their fuel/technology and their company in the relevant market. Given the large share of oil in global energy supply, oil majors can translate emissions targets into the impact for oil. In contrast, the initially small share of renewable technologies in global energy supply means that such calculations are more speculative for investors in new energy technologies, and additional guidance on the role envisaged for these technologies is frequently sought.

	Oil majors	***Technology companies***	***Large utility companies***	***Banks, Project investment***
Historic prices			Replication of successful strategies	Required to calculate volatility

Current price	Determines operation	Short-term production	Perceived as best guide for future	Main input for base case
Future prices	Difficult to predict	Difficult to predict	Valuable where available	Value long-term contracts
Future market share of fuel/technology	Main driver for strategic choices	Main driver for strategic choices	Sometimes used in modelling	

Table 3.1 Main determinants of investment choices across sectors

Large utility companies have traditionally based their decisions on the national regulatory environment, best reflected in current and future prices and in the case of EU ETS the level and methodology of free allowance allocation. For banks and project investors, carbon and energy costs are often a minor part of their decision process and are best dealt with using standard metrics based on historic volatilities, current and forward prices. The challenge for low-carbon policy will be to address these different requirements so as to ensure low-carbon investment is pursued by the different market participants.

3.4 Addressing requirements of players with long-term perspectives

Any investor would wish to have reasonable certainty about future policy evolution. However, in a world with scientific, technological, economic and political uncertainty, policies that promise certainty for a long term horizon are not credible. Policy design needs to balance regulatory certainty with flexibility to respond to uncertain future impacts, which can be achieved by moving from general long-term objectives, towards more specific mid-term targets and effective short term policies. In such a framework, robust policies implemented today provide the credibility for longer-term targets, and these targets provide guidance for strategic investors and technology companies.

The general principle of moving from broader long-term objectives towards more tangible mid-term targets and short-term policies is uncontroversial. The definition of specific time frames and targets is typically more challenging.

When setting long-term emissions targets, policy makers have to balance the risks and costs of climate impacts against the feasibility and costs of emissions reductions. [42] With increasing robustness of climate modelling, the majority of scientists warn against temperature increases above 2^0C. The economic modelling of the costs to reduce emissions towards an emissions trajectory compatible with a 2^0C temperature increase is still uncertain, as reflected by the variability of results across modelling teams. Nevertheless, few models anticipate prohibitive costs, and usually costs are modest in the range of 1% loss of GDP (Stern Review 2006). The stabilisation scenario of 500-550 parts per million CO_2 equivalent that was basis for the Stern Review creates, according to best estimated of the recent report of Intergovernmental Panel on Climate Change (IPCC 2007), average temperature increases between 2.4^{0}C to 2.8^{0}C. This suggests that climate policies will have to limit global CO_2 concentrations at 450 parts per million CO_2 equivalent. Fewer models have assessed the corresponding scenarios, but all of these predict GDP reductions smaller than 3.3% by 2030 (IPCC 2007).

As emissions reductions are translated into shorter-term targets for countries and sectors the risk perception is shifted. Any one sector or actor considers the impact of individual or sectoral decisions on global climate change as small, and their main concern is the risk for profitability of the business. Listening carefully to industry concerns, policy makers will therefore be reluctant to pursue any policy that creates any significant risk that a specific sector might face difficulties and prefer to implement a lenient policy if required to avoid this risk.

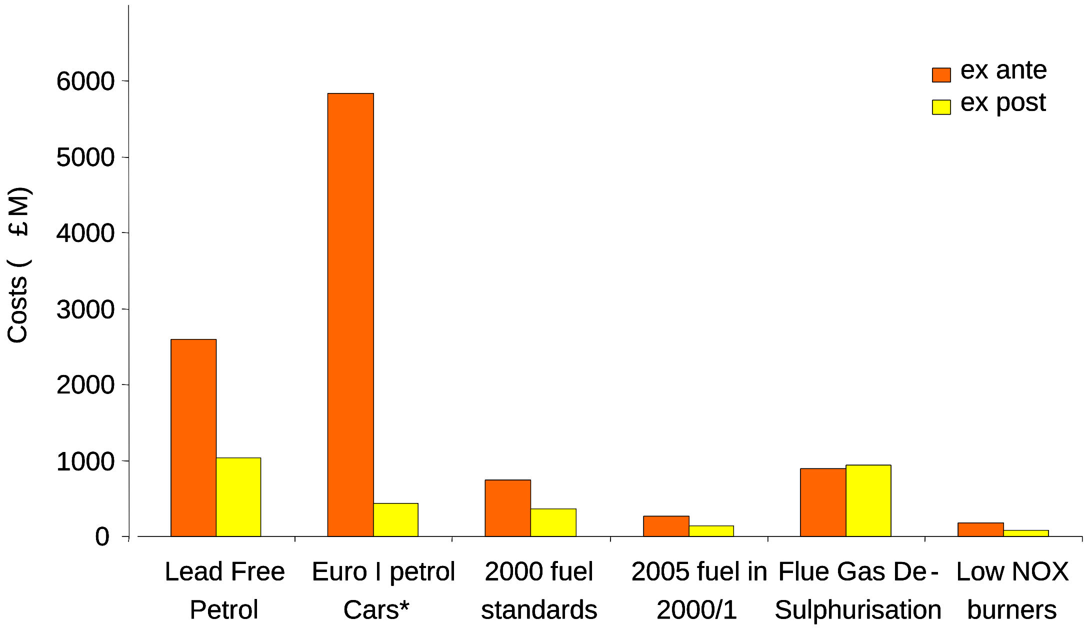

Figure 3.9 Ex Ante and Ex Post cost of UK policies (AEA Technology Environment 2004)

In addition, a number of studies (e.g. Harrington et al (2000) and Hammitt (2000) have found a continuous discrepancy between higher *ex-ante* costs estimates and lower cost options observed in *ex-post* assessments.[43] To illustrate, figure 3.9 shows the comparison of ex ante and ex-post evaluations of UK environmental air quality regulations. Business and government over-estimated costs of implementing measures to comply with the regulation. The comparison with ex-post evaluations shows that costs can fall with innovative ideas and optimisation of technology during mass production based on learning-by-doing.

The discrepancy between the risk aversion of different actors involved in bottom-up policy processes and top-down target setting comes to light when mid-term targets are set and legislation is created, for example in cap and trade schemes. To set effective and credible targets this discrepancy has to be resolved, which requires analysis and shared perspectives on how individual sectors could evolve from their current situation towards a low-carbon future.

The first important aspect of aligning the perspectives is the ability to pool risks across sectors. Any one sector faces many uncertainties as to whether technology improvements will allow for energy efficiency improvements and emissions reductions, and will therefore be reluctant to accept stringent targets for the sector. Cap and trade schemes, which cover several sectors, involve many different possibilities for technology and process improvements, and can therefore set more ambitious targets. This suggests a benefit of cap and trade schemes over sector specific agreements, but the benefit will only be realised if the cap setting is clearly separated from the allowance allocation process in the scheme as discussed in chapter 2.

The second aspect that needs to be considered when aligning perspectives is the time-frame over which targets are set. The European debate has converged on the 2020 horizon, while many proposals discussed in the US Senate outline targets for 2030.

A 2020 time-frames make the results more tangible for current investors but leave open the question about the level of ambition beyond 2020. This has a benefit that it allows for decisions on the specific trajectory beyond 2020 in response to the ongoing discussion among policy makers and populations as they are gradually acknowledging scientific evidence on climate change. Shorter time frames of target settings allow a sequential commitment to more ambitious emissions reduction targets and policies.

2030 time-frames are further away from bottom up policy processes and can thus allow for more ambitious targets. To be tangible for investors, these targets require a clear trajectory or specific milestones. Discussions about these shorter-term objectives will open up debate about discrepancies between bottom up and top down approaches. Otherwise, initially long-term targets might be set too leniently. They might then have to be tightened, which would create some uncertainty. Transparent processes, which ensure that targets are only tightened and not relaxed over time, are required to provide a stable framework for low-carbon investment.[44] The alternative, large scale banking of allowances under an initially lenient cap towards more stringent caps post 2020 is tricky. Such banking was common practice in SO_2 trading schemes in the US, but the value of carbon allowances is significantly bigger, and if similar shares of allowances are banked hundreds of billions of dollar asset value would be involved. It is difficult to see how private actors would hold assets that are subject to significant regulatory risk, without large risk discounts that would depress the carbon price and delay investment decisions.

It is easy and popular for politicians and governments to declare long-term targets. But by themselves these targets are not very informative. Political parties and governments have to demonstrate their commitment to these targets by investing political capital in shorter-term policies to support the long-term targets. They can do so by implementing low-carbon policies even when they face opposition from influential political lobby groups. Such government commitment gives private sector investors confidence that future governments are also likely to pursue stringent policies. This in turn attracts investment in technology development and low-carbon choices (Helm et al 2003).

The evolving policy framework in Europe

Figure 3.8 summarises some components of European climate policy. Member States and the European Commission want to avoid emissions trajectories that result in more than 2^{0}C temperature increase. This requires that European emissions are reduced by 60%-80% relative to 1990 levels in 2050.

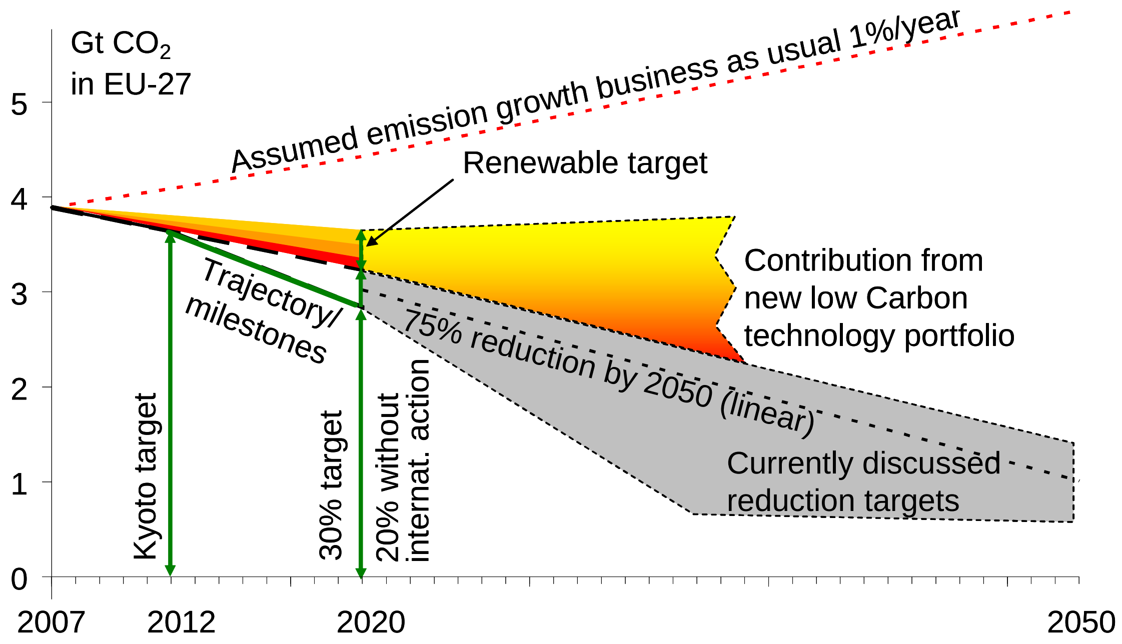

Figure 3.8 Components of a low-carbon perspective

The long-term objectives have been translated into more tangible mid-term targets. In March 2007 the heads of European states approved in the European Council the necessary mid term-targets. In January 2008 they were translated by the European Commission into a set of draft Directives, the Climate Package, which is expected to be passed by the European Parliament and Council by December 2008.

With these Directives the European Member States commit to achieve a reduction of at least 20% in the emissions of greenhouse gases by 2020 compared to 1990 levels, and the objective of a 30% reduction by 2020 subject to the conclusion of a comprehensive international climate change agreement. In addition 20% of final energy consumption is to be met from renewable energy sources. Although this renewable target reduces the flexibility in delivering the emissions reductions, it is part of the strategy to support the development, diffusion and scaling up of low-carbon technologies required for deeper cuts post 2020.

For strategic investors these targets will be tangible enough to inform investment choices between technologies with different carbon intensities. However, for the development and initial deployment of technologies like solar photovoltaic, marine energy technologies or carbon capture and sequestration, the 2020 emissions targets are unlikely to offer much guidance, because these technologies are unlikely to make a big contribution to the 2020 emissions reductions. These technologies are, however, expected to deliver large scale emissions reductions by 2030 and beyond. To achieve this contribution, they have to be developed and reach production scale by 2020. Currently the European policy framework does not explicitly address this requirement. Perhaps the implementation guidelines of the renewables Directive might be a suitable place to require Member States to outline their trajectories for renewable technologies beyond 2020. This would likely require that Member States implement suitable policies to support early stage renewable technology.

The experience with the pilot phase of ETS suggests that mid-term targets need to be translated into milestones or emissions trajectories. In the absence of either, some governments submitted National Allocation Plans for the period 2005-2007 that were not on a linear trajectory towards the 2008-2012 emissions reduction targets under the Kyoto protocol and EU Burden Sharing Agreements. The governments argued that they could delay action providing they implement policies in the future to rapidly reduce emissions. As long as there is limited empirical evidence on low-carbon policies, it is difficult to disprove such claims. The European Commission therefore proposes in the Draft directive of January 2008 that Member States shall annually limit their greenhouse gas emissions in a linear manner, and applies a similar approach to the installations covered by the European Union Emissions Trading Scheme.

The clearly defined trajectory for emissions reductions and technology development is required to ensure that national governments pursue low-carbon policies in the short-term. These policies will reward low-carbon investments today and create market confidence that new low-carbon investment will benefit under future low-carbon policies. This situation can be compared to credit markets: a borrower has to meet his ongoing commitments to reassure banks that he will pay back new loans in the future. Just as credit history is a major criterion for banks to decide on private loans, likewise the history of low-carbon policies is a major criterion for investors.

To summarise, investors with long-term perspectives on the role of technologies and market shares require mid-term emissions reduction targets. These targets have to be credible. Credibility flows from a consistent set of long term objectives, mid-term targets for emissions and low-carbon technology development, and shorter-term milestones or trajectories. But the basis for all credibility remains the political commitment. Private sector investors will carefully measure this commitment by observing policy makers in their daily decisions – do politicians invest political capital and implement climate policies even where they face opposition from important stakeholders.

3.5 Addressing requirements of project investors

If carbon is not the core component of a project, investors deciding on projects and banks providing financial assistance rarely engage in long-term policy analysis of carbon policies. Instead they use historic and current financial indicators, and take current market design and regulation as the best guess for what might be in place in the future.

This situation constitutes a challenge for decarbonisation policy with few historic carbon prices, volatile current prices and an evolving future policy framework. Particular concern for low-carbon investments is the risk of low or zero carbon prices. As it is difficult to predict the probability of such events, investors and banks err on the safe side and assume higher likelihoods. As a result an uncertain carbon price might have a similar adverse impact on investment and financing decisions as a zero carbon price.

In the following sections we will discuss different options to increase confidence in carbon prices until the price is firmly established, so as to facilitate low-carbon investment.

3.5.1 Length of implementation periods

Increasing the length of periods for which cap and trade schemes are implemented is frequently discussed as one approach to increasing price stability. An argument in favour of long-term periods is that when the trading periods are too short, the scarcity of allowances in the system, and thus the allowance price, will be too sensitive to climatic conditions like a cold winter or short-term economic cycles with a temporary increase of economic activity and thus emissions. With longer trading periods these impacts would be averaged out over more years and would thus have less of an impact on the allowance price. Also, longer trading periods will mean there is more time for investors to respond to high allowance prices with investments that reduce emissions and eventually prices. With longer trading periods, however, the uncertainty inherent in projecting future emissions levels will increase. Figure 3.10 illustrates the results of several power and non-power sector models that were combined to project EU-25 emissions for the period 2008-2012.[45] The results were calibrated on the verified emissions from the emitters in 2005. The significant uncertainties inherent in the projection reflect different assumptions on economic growth, fuel prices and energy efficiency improvements. With longer trading periods, these uncertainties will increase, suggesting that the allowance price required to clear the market might deviate even further from initial expectations.

Also, as the length of implementation periods is increased, so is the likelihood that constraints on emissions will have to be tightened again during the trading period. Any political discussions on possible tightening will be reflected in the prices and thus increase volatility.

Not only the final cap, but also the methodology of allowance allocation influences investment decisions.[46] In some cases it might be easier to make a long-term commitment to the methodology of allowance allocation (e.g. full auctioning) even for a time period for which no explicit emissions cap can be determined. Thus a stable framework outlining future allocation decisions can facilitate investment decisions for time horizons for which final caps are not yet determined (Ahman et al 2007).

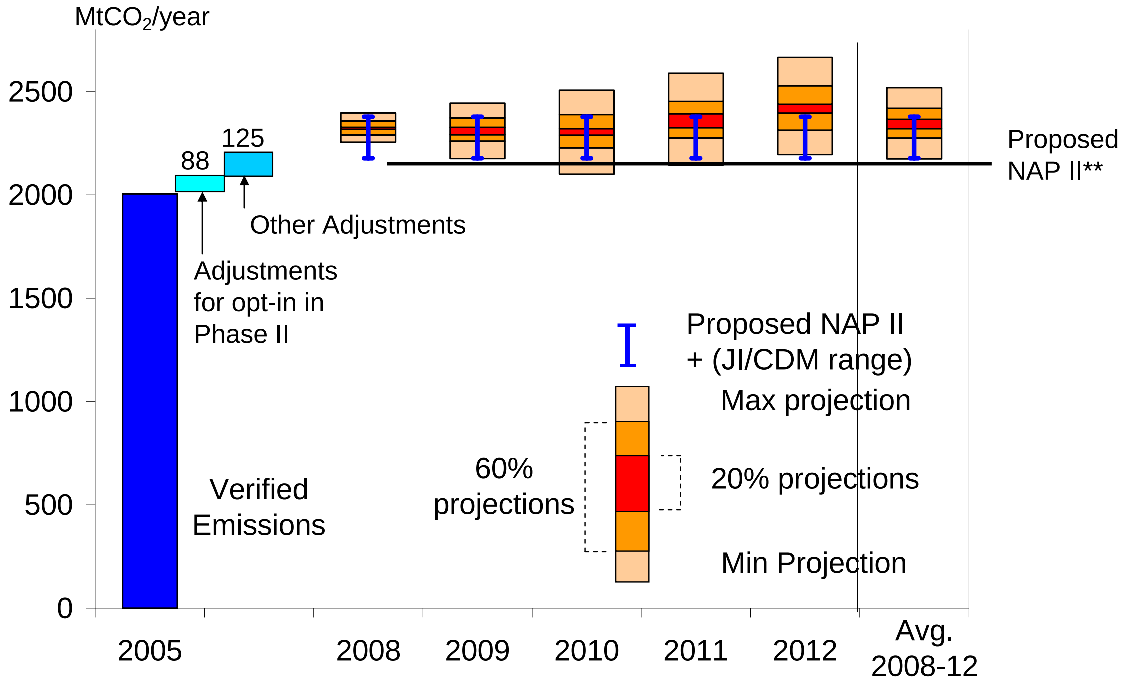

Figure 3.10 Emissions projections for period 2008-2012 based on verified emissions in 2005, EU25 (Neuhoff et al 2006)

3.5.2 Banking and borrowing

Allowing for banking is often suggested as a means to increase price stability – and we discuss lessons from US experience, the first EU trading periods and implications for future policy design.

The USA SO_2 cap and trade schemes also allocated far more allowances for the first years than were required to cover emissions, but, the allowances were defined as bankable: firms could keep – or bank – unused allowances for future use, which many did because the cap was expected to be tighter. As a result, the allowance price did not drop to zero despite excess supply (Ellerman et al 2000).

To what extent policy design should expand the role of banking, and increasing the allowance supply so as to create some excess allowances that will be banked is influenced by various factors.[47] In the USA SO_2 cap and trade scheme it was possible for policy makers to offer a long term horizon. The need for emissions reductions was well established, and the technology to tackle SO_2 was widely available and used. Thus banking between periods occurred in a stable regulatory environment. Although 31% of allowances were banked in

Phase I of the US Acid Rain Programme, the overall value of these allowances was still limited to a few billion dollars.

The situation differed markedly from the pilot phase of EU ETS that did not allow for banking of allowances into the second period. Already in 2006 the excess supply of allowances had become apparent and the price of allowances dropped to virtually zero by 2007. Banking was not envisaged, so as to prevent spill-over from possible difficulties in the pilot phase in the Phase II. This ensured that EU ETS makes its contribution towards the Kyoto emissions targets, which are measured over the period. 2008-2012. Indeed, despite the crash of the price of allowances for the pilot phase, the forward price of allowances for Phase II remained robust. For subsequent phases, the EU Directive allows for banking.

It is still debated to what extent the design of the cap should rely on banking to create scarcity. It is undisputed that banking of CO_2 allowances between trading periods can avoid price drops at the end of a trading period. But should a cap and trade scheme be designed in a way that anticipates that a significant share of allowances will be banked to the next trading period, and therefore rely on banking as the primary mechanism to determine the allowance price? It is sometimes argued that this type of banking between periods can increase the price stability (Newell et al 2005).The approach also offers the benefit of avoiding price spikes if market participants struggle to reduce emissions to the overall cap level. The approach does however create three challenges.

First, if there is an explicit recognition that initial caps are loose and higher then the desired then they do not help market participants and policy makers to coordinate activities that are required for a transition to more carbon efficient buildings, transport infrastructure or supply chains. The benefits associated with emissions trading schemes – to deliver a carbon price that supports the shared vision of an emissions reduction trajectory – is lost.

Second, carbon policies and trading schemes are still evolving and neither the trajectory towards long-term stabilisation scenarios, nor the technologies eventually applied to deliver the necessary emissions reductions are established. If market participants expect that future allowance prices will be higher, they will buy allowances today to bank them for the future, thus increasing the current price levels. [48] Large scale reliance on banking can thus increase the impact of future climate policy discussions on current carbon prices.

Third, if significant shares of allowances of carbon trading schemes were banked, then their value could reach for example in the US hundreds of billions of dollars by the year 2020. This requires careful analysis as to which private sector entities would be prepared to hold allowances of such a value without charging a significant risk premia to reflect policy uncertainty.

Sometimes it is suggested emitters should be allowed to borrow allowances from future periods. Emitters that cannot cover their emissions with current allowances would be allowed to surrender the necessary allowances in future periods. However, because of the various risks associated with such borrowing it has so far not been permitted. First, emitters might default or gradually increase their allowance debt, requiring complex collateral requirements. Second, it is difficult to anticipate how many allowances will be borrowed, therefore allowance scarcity and prices are more difficult to anticipate. Finally, governments might not be able to make up the excess emissions of emitters that ‘borrowed’ allowances from future periods by increased emissions reductions in sectors not covered by the cap and trade scheme, and would therefore fail to deliver against their internationally agreed emissions reduction target. If governments themselves could borrow from future periods, then they might be tempted to try to negotiate more lenient targets to make up for their excess emissions. This distortion of incentives for policy makers is the biggest concern regarding borrowing.

3.5.3 Active government intervention

Investment decisions and access to finance for low-carbon projects can be significantly affected by a perception that carbon prices might fall to low levels. Policies addressing this risk can facilitate low-carbon investment. They can build on a long history of government intervention as the examples of export credit guarantees or strategic oil reserves illustrate. Commodity price stabilisation has been popular and continues to be applied, particularly to reduce risks for small farmers (Newbery and Stiglitz 1981). However, commodity price stabilisation frequently failed because (i) storage costs are high, and (ii) coordination among multiple countries is difficult.

Some authors have explored the potential role for an independent carbon committee or bank to guard stability of carbon prices (Helm et al 2003). One idea is to equip such a committee with similar tools and powers that are available to independent central banks for their management of currencies, for example to avoid inflation. Politicians have an incentive to print money so as to accelerate growth and increase public spending. However, the benefit of printing money is of short duration because it is quickly followed by increasing inflationary pressure. Independent central banks can delay a government intervention by a few months and thus eliminate the short-term benefits of printing money.

This example does however not lend itself for climate policy, because the time frames of carbon markets are different. Imagine politicians who want to respond to the interests of incumbent firms in the carbon-intensive sectors and reduce the carbon price. From their perspective it might be worthwhile to spend some months convincing the carbon bank to issue extra allowances, because the allowance price would already fall in expectation of this outcome at the beginning of the effort. The negative impact on future low-carbon investment would only be felt in future years, not in the next months. Hence the institutional independence would be unlikely to offer sufficient protection over the relevant time frames to guarantee a robust carbon price. An institution that can make discretionary interventions in the carbon market is unlikely to be sufficiently credible to create investors' confidence in a robust carbon price.

3.5.4 Setting a reserve price in auctions

Governments can announce a reserve price for allowance auctions. Assuming that a sufficient fraction of allowances is to be auctioned, the reserve price will translate into a price floor for carbon allowances because some of the allowances from the auctions will be required to satisfy demand. Consequently, all trades will be at or above the reserve price level.

A price floor implemented via a reservation price can create confidence of market participants for the duration of the trading period, and help control price volatility. Market participants might also interpret a reservation price in one trading period as the most likely reservation price in subsequent trading periods.

Implementation of such a reserve price requires cooperation between countries that have a joint cap and trade scheme (e.g. EU Member States). If only a fraction of the allowances envisaged for sale are auctioned because demand is limited at the reserve price, then in principle every country would like to be the first to sell its allowances. Individual countries might try to pre-empt each other to sell their allowances (Hepburn et al 2006). Some form of coordination is necessary to ensure that all countries sell a similar fraction of their allowances. An informal approach towards such coordination could be easily found. For example, several governments can commission one commercial agent to auction allowances according to a specified protocol on their behalf. If the reserve price was binding, then the agent would return unsold allowances to the respective governments proportional to the total volume of allowances each country intended to auction.

In addition excessive inflows of CDM or JI credits have to be avoided if there is a risk that these could be available at sufficiently large volumes at prices below the reserve price. Policies like the supplementarity condition requiring that part of the emissions reductions have to be delivered domestically and limit inflows of allowances can address this issue.

3.5.5 Put option contracts

Governments can issue put options on future allowances and distribute them widely among market participants.

Option contracts are commercial agreements between governments and private buyers and are as such well protected by property rights. Thus they can allow governments to credibly commit to a minimum level of stringency of future carbon policy and facilitate investment in low-carbon technologies.

Governments would sell the options to market participants, which can subsequently trade the options. At the time of the expiry date, if the allowance price is below the strike price, the owner of an option can return it alongside a carbon allowance to the government (physical clearing). In return the owner will receive the defined strike price. If the allowance price is above the strike price of the put option, the put option will have no value. Text box three illustrates how the mechanism works.

An alternative approach for governments would be to issue a contract-for difference (CfD) with investors on the future carbon price. The holder of such a contract would be entitled to receive the strike price stated in the contract less the actual price implicit in any carbon instrument that applies to fossil generation. If the carbon price exceeds the strike price, then the holder of the contract would be required to pay the difference. Thus CfDs can create significantly financial exposure, and counter party risk, if the holder of the contract does not benefit from the high carbon price if for example its production capacity is down.

The main motivation for governments to engage with financial instruments that allow for hedging of carbon price volatility is that for the investing counter-parties they do ensure that the political risk is borne by the government, not the investors (Grubb and Newbery 2007). They may face resistance from governments reluctant to bind themselves to such future liabilities in the event of a weak carbon price. However, because the investment risk in this respect intrinsically arises because of uncertainty about future policy, there is a compelling case that governments should bear these risks directly in respect of long-term, low carbon investments.

Text box 3: Government issued put options to guarantee a price floor

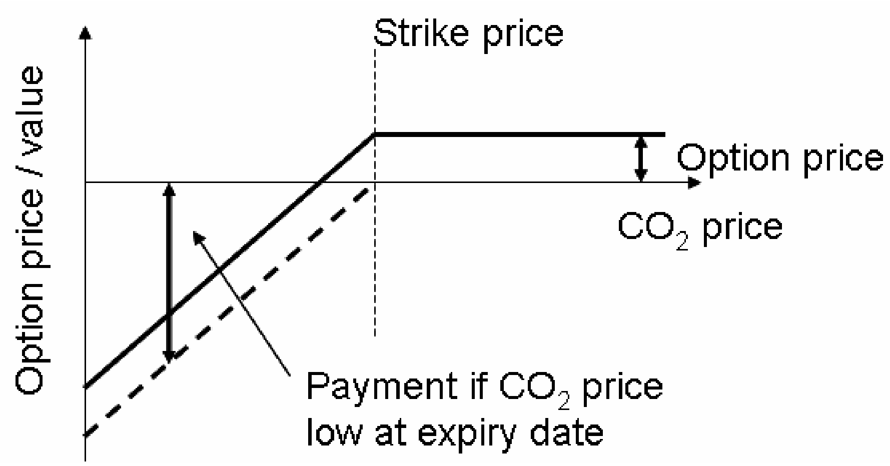

Figure 3.10b Put options on the price of carbon

Figure 3.10b illustrates the scheme with a simple example. The government promises to maintain the price of carbon emissions at or above €15. In order to do that, the government issues one hundred million put options on EUAs with a strike price of €15 and duration of five years. If the price of EUAs falls to €10 at the end of the five-year period and assuming infinitely elastic supply of allowances at such price, option holders would buy an EUA on the market for €10 and sell it, using the put option, for a price of €15 to government. The government would then have to spend a maximum of €1.5 billion (one hundred million times €15). This would, however, be counted against the initial sales revenue from allowances and option sales. Anticipating the need to reimburse option holders, the government will *ex ante* sell fewer allowances. In addition, there will be a second effect: *ex post* (i.e. after the government has issued the allowances), holders of the put option will, through their purchase of the allowances, drive up the carbon price thus automatically stabilizing prices. If the amount of option contracts issued is sufficiently large, then the scheme effectively creates a floor of €15 for the allowance-price. The policy objective is satisfied without triggering a financial penalty for the government – creating a win-win situation.

This shows that put options provide investment security from three perspectives (Ismer and Neuhoff 2006). First, investors in projects that are at risk from carbon price uncertainty can limit their downside risk. Second, if the authority has issued many put options, then market participants will buy allowances from the market and return these with the option to government should the allowance price fall below the strike price. This will in turn reduce the volume of allowances in the market, increase scarcity, and push the allowance price up. With sufficient put options in the market, the allowance price will not fall below the strike price of the option. Third, an authority that issued too many put options is aware of the financial liability it would incur, and so it will pursue prudent carbon policies and adjust its issuance to avoid the large financial liability that would be triggered if the carbon price fell below the strike price of the options.

The maximum amount of the authority's liability equals the strike price multiplied by the number of put options handed in; the profit made by the third party per put option would then be the strike price minus the allowance price. In particular, the put options allow investors in abatement technology and in renewable energy to hedge against the risk that lower carbon prices reduce production costs of high carbon products and services.

3.5.6 Price cap

Unexpected events can create emissions levels that exceed the national targets. Cap and trade schemes respond to such events by price increases that trigger additional mitigation efforts in the remaining years of a trading period and by reducing the volume of allowances banked into the next trading period. It is sometimes discussed whether additional flexibility is required to respond to unexpected emissions increases that increase the price of allowances.

Pizer (2002) argues for hybrid schemes combining a trading approach with a price cap. To implement price-caps governments could for example make additional allowances directly available to the market once the allowance price exceeds a price cap (Jacoby and Ellerman 2004). But if such a price cap were set too low, then this can undermine the credibility of future emissions targets. The price cap might prevent future price increases that are necessary to reward investors in low-carbon technologies and projects. In this case low carbon investment will not come forward. Thus low price caps might result in higher emissions and ironically in the long-term higher average allowance prices.

During the introduction of a cap and trade schemes it is most difficult to determine the appropriate emissions cap – and thus this might be the occasion where a price cap is most justified. Again, to repeat the previous point, the legislation would have to clearly specify the expiry of the price cap after two or three years, so as to ensure that the allowance price can create the necessary incentives for low-carbon investments.

The Clean Development Mechanism could offer an alternative opportunity to avoid unacceptably high allowances prices. To increase short-term flexibility to cover a shortfall, governments might consider permitting crediting not only delivered emissions reductions but also some of the future emissions reductions that will be delivered with a CDM project. [49]

3.6 Conclusion

It is generally agreed that large-scale emissions reductions will hinge on investment in low-carbon projects, infrastructure and technology. Private sector companies are responsible for the majority of investment choices and so policy instruments have to influence their decision making processes.

Credible mid- and long-term targets will guide corporate strategy and strategic investments, and thus facilitate development and deployment of new technologies. The commitment of governments to future targets will be judged by the policies they implement today. The perceived consistency of future targets and credibility of current policies depends on government and industry stakeholders developing a shared vision of the transition towards a low carbon economy.

Predicting the future carbon price that will be part of this vision is, however, difficult – and perhaps not even necessary. After all, the future carbon price has to respond to fuel and commodity prices, and reflect the costs of low-carbon technologies. Thus it is not commitment to a specific future carbon price, but the credibility that the future carbon price will adjust to a level consistent with the emissions target that is required. Cap and trade schemes can offer a mechanism to delivers this carbon price.

In the short-term simple and transparent policy instruments that reduce the risk of low-carbon prices can facilitate investments in low-carbon projects. They can also influence investment in carbon-intensive projects if internal and external supporters of such projects use uncertain carbon prices as an excuse to continue to pursue projects that were initiated without considering the implications of climate policy. Carbon taxes would offer the necessary simplicity. Cap and trade schemes can also deliver price floors, for example when combined during the initial years with components such as reservation prices in allowance auctions or government issued put options on future carbon prices.

This chapter continually referred to the role of national governments. Even though companies act in global markets and climate policy is on the international agenda, national governments still have a considerable role to play. This raises the question of whether national governments can credibly implement low-carbon investment frameworks while the international regime is still evolving. The next chapter discusses the possible evolution of national and supra-national initiatives towards a global effort.

4 Evolving sectoral and regional coverage

Key messages:

- *Timing to include sectors into domestic carbon trading scheme has to reflect:*
    - *Existing regulation, taxation and consumers' sensitivity to price change.*
    - *Sector specific responsiveness of investment and innovation to carbon price.*
- *Design emissions trading so countries with similar ambitions can link schemes:*
    - *Institutional setting has to be robust for carbon price to support investment.*
    - *Avoid situations where countries are less ambitious to avoid financial flows.*
- *Project based mechanism is only the first step to cooperate with developing countries:*
    - *Expensive to support low-carbon projects when energy is subsidised.*
    - *Leverage co-benefits of climate policy for technology and energy security.*
    - *Explore new options to cooperate on implementation of domestic policies.*

The Kyoto protocol was often envisaged as the introduction of one global carbon market for all developed countries that would eventually be joined by developing countries. As of 2008 we are instead observing a multitude of different cap and trade schemes being developed across Europe, Australia, New Zealand, some USA states and Canada.

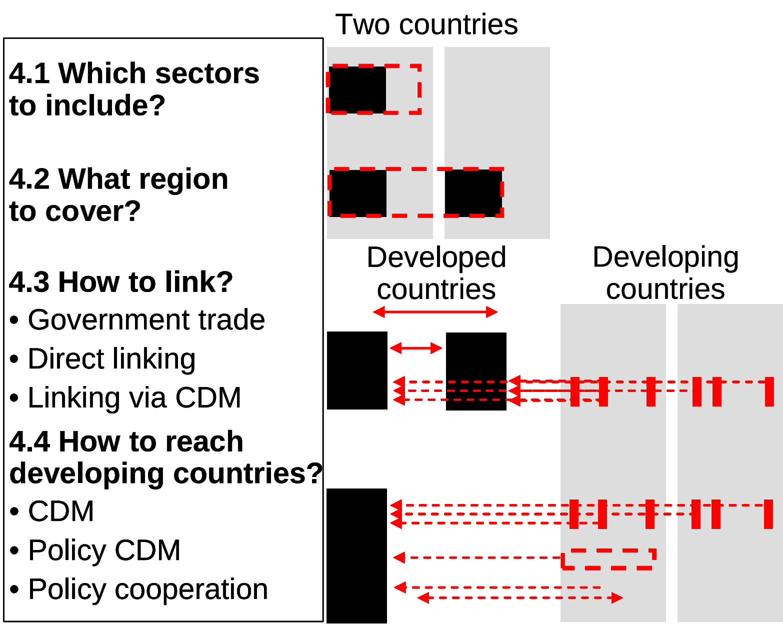

Figure 4.0: Structure of the chapter

This chapter discusses the choice of sectors which are covered by carbon pricing schemes (section 4.1) and the criteria for the determination of the regional coverage of joint carbon pricing schemes (section 4.2). Section 4.3 discusses how trading schemes that are initially implemented separately can be linked, including by trade between governments of emissions under the national target, direct trading between the schemes, and indirect linkages via projects accredited under the Clean Development Mechanism. In section 4.4 mechanisms to engage developing countries in climate policy are discussed.

4.1 Selecting sectors for inclusion in cap and trade schemes

Cap and trade schemes that are currently implemented in Europe and proposed elsewhere differ in the range of sectors they cover. Whereas the European scheme covers power and industrial installations bigger than 20 MW (thermal), the Regional Green House Gas Initiative (RGGI) of the east coast of the USA limits coverage to the power sector, while the proposed Australian scheme extends coverage to the forestry sector. The philosophy underlying many of the discussions is that eventually coverage should be expanded to the whole economy. This raises two questions. First, should carbon pricing be applied to all sectors simultaneously or is there merit in using different policy measures across the sectors through a transition period? Second, if cap and trade is used as an instrument to deliver the carbon price signal, should it be applied to a specific sector or cover all sectors? This section discusses the criteria that might explain why results depend on the starting point of countries and may differ across countries.

Carbon pricing is implemented in a world of pre-existing taxation and regulation. Figure 4.1 illustrates the relative importance of energy taxes, regulation and carbon pricing for different sectors. Fuels to heat buildings are frequently subject to lower tax rates. Buildings are instead subject to increasingly stringent regulation for insulation or energy efficiency. Gasoline taxes in the transport sector are relatively high; for example in Europe, they are a multiple of even the highest prices observed under the Emissions Trading Scheme. In contrast, energy intensive industries have frequently been exempt from energy related taxation and from regulatory energy efficiency measures.

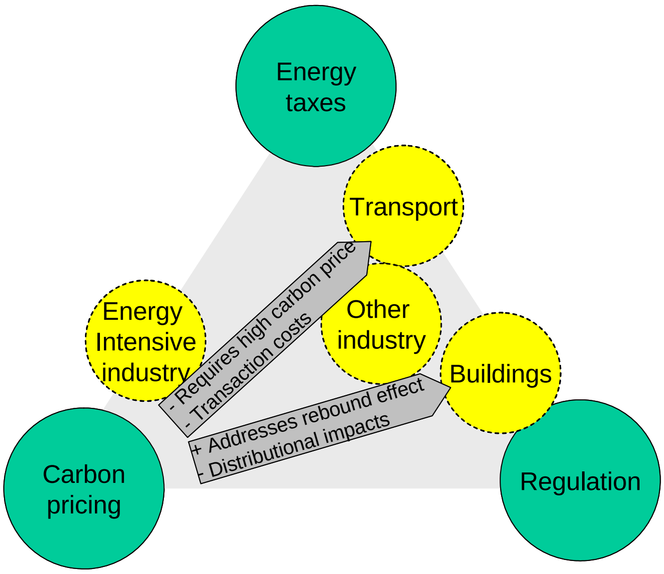

Figure 4.1 Energy taxes, regulations and carbon pricing differ in their importance for sectors – policies to expand the scope of carbon pricing have to be evaluated within this framework.

4.1.1 Benefit of including a sector into the scheme

Against the background of existing energy taxation, the case to include a sector into a carbon pricing scheme depends on the role that the carbon price is expected to play in driving substitution, investment choices and technology innovation.

The level of substitution delivered from carbon pricing will differ across sectors. The incentives will be higher for carbon-intensive products – after all the purpose is to move demand from high to low-carbon choices. This can best be illustrated with two products with similar demand elasticities. Assume the production of the first results in twice the carbon emissions of the production of the second. A carbon price increase will increase the price of the first product by twice the amount of the second product. As a result of the bigger price increase, the demand reduction for the first product will be twice as great. This suggests that it is important to deliver the full carbon price signal to sectors and activities that are carbon-intensive like aluminium, cement, steel, or basic chemicals. In addition, this will also create the strongest incentives for innovation of substitutes for the high carbon products and services. The same argument dictates that the demand response of the carbon price signal will be lower in sectors with high energy taxation - the cost increase relative to pre-existing costs will be smaller, as will be the demand response. Thus implementing the carbon price will be most effective and should have priority in sectors that face low energy taxation or even receive energy subsidies.

With regard to incentives for innovation, the carbon price signal plays, in principle, the same role in rewarding low-carbon technologies across sectors. However, as discussed in chapter 1, sectors differ in the extent to which the carbon price signal will be the main driver for innovation. Thus delivering the carbon price signal is more important in industrial sectors with complex production processes as governments have fewer opportunities to support innovation in such environments than in sectors, like renewable energy, where strategic deployment programs can be used to drive innovation.

From the perspective of the overall scheme, volatility of the allowance price could increase if large sectors that have low responsiveness to carbon prices are included. For example, if road transport were included in the cap and trade scheme, any changes in transport emissions would alter the scarcity levels of the trading scheme. With high pre-existing fuel taxes road transport is less responsive to the carbon price signal. Thus other sectors covered by the cap and trade scheme will provide most of the response to changes in emissions of the transport sector. This might create unexpected price changes and increase volatility of the carbon price. However, it could also result in a reduction of volatility as an increase in the number of sectors covered by the cap and trade scheme reduces the influence of any one sector.[50] A careful quantification is required to understand the overall merits of sectoral expansion.

4.1.2 Challenges of including sectors into the scheme

The benefits, which can potentially be delivered by inclusion of a sector into a carbon pricing scheme, have to be weighed against the (political) costs created by the redistribution of rents, concerns about international competitiveness and transaction costs of the scheme.

Politically it is more difficult to deliver a carbon price to sectors where it redistributes rents with significant equity implications. This complicates the application of a carbon price signal to sectors like domestic heating in countries where energy use for domestic heating is high. If, however, carbon prices gradually increase as assumed in many projections, then it might be all the more difficult to include these sectors in the future as they would then face an abrupt change from no carbon pricing to a high carbon price. Allocation of free allowances to domestic users, or using auction revenues to compensate households for cost increases, might be a more effective way to address the equity concerns than excluding a sector as discussed in chapter 2.

There is some concern that sectors producing internationally traded or tradable carbon-intensive products will redirect investment or shift production to countries with lower carbon prices. It is sometimes suggested that such sectors are excluded or shielded from the full carbon price signal. However, these are the sectors where a functioning carbon price signal would have the biggest impact on reducing demand and carbon emissions. After all, they are carbon-intensive and often face low levels of energy taxation. Chapter 5 assesses which sectors would be at risk from leakage due to carbon price increases rather than demand reduction, and presents the different policy options to avoid such leakage.

Transaction costs are frequently cited as a constraint on the inclusion of small emitters into a cap and trade scheme. In the EU ETS the threshold for ‘small’ emitters is set at 20 MW thermal power. The continued debate as to whether to increase or decrease this threshold suggests that the threshold is roughly correct, balancing the transaction costs of including smaller emitters in the EU Emissions Trading Scheme against benefits. One way to reduce transaction costs is to apply cap and trade not at the level of individual emitters but further upstream. Carbon emissions from energy consumption are directly proportional to the consumption of fuel. Therefore it is sufficient to measure fuel consumption, which can easily be done at the level of refining and imports. In an up-stream scheme, refineries or oil importers could be required to obtain allowances to cover carbon emissions that will result from the later fuel use.

Despite the simplicity that upstream schemes offer, they have not been applied for large emitters because they are not suitable for free allowance allocation that can create political support for the initial implementation and they do not create monitoring, reporting and direct accountability at the emitter level and thus forgo the direct involvement of emitters to encourage changes of operational and investment decisions.

4.1.3 Timing of inclusion

From the perspective of individual sectors an early inclusion into the cap and trade scheme might have the benefit that the sector is exposed to the trading scheme when the carbon allowance price is still moderate. As governments pursue more stringent climate policy, the sector will then adapt and innovate with gradually increasing carbon prices. This argument hinges very much on the level of confidence people have in the potential of new technologies. If analysts are right to argue carbon capture and sequestration and other options can eventually deliver most of the necessary decarbonisation at prices between 30 and 60 €/tCO_2, then there is little increase to be expected from carbon prices that have already reached 30 €/tCO_2 in the pilot phase of the EU ETS. If future carbon price increases are not substantial, then the argument that early inclusion facilitates gradual adjustment to higher carbon prices is of little relevance.

4.1.4 Governments' responsibility for sectors in a cap-and trade scheme

Does inclusion of a sector into a trading scheme relieve government from responsibility for emissions of that sector? If carbon pricing is understood to be only one component of a policy mix in which complementing policies are required, then governments need to retain overall responsibility for emissions. The management literature can help to find the right balance – after all it is a typical management challenge how to best delegate a task while retaining overall responsibility for the delivery of the result.

Indeed, the same art of balancing is required in climate policy as in management. If, on the one hand, a government takes its responsibility for overall emissions reductions as a mandate to micro-manage the economy in order to deliver every ton of emissions reductions with a targeted policy, then the carbon price signal, economic efficiency and incentives for innovation offered by the market based approach are lost. If, on the other hand, a government is too hands-off, then market participants will not be able to deliver expected emissions reductions because, for example, diffusion of new technologies is not supported by appropriate institutional and regulatory frameworks. But if the scheme does not deliver the necessary emissions reductions then government will eventually intervene and adopt different policies. Thus a totally hands-off approach might undermine the credibility of a scheme as much as overly interventionist policies.

A good carbon policy involves finding a balance between delegating to market based instruments, providing regulatory and institutional frameworks, and enforcing targeted technology policy. The right balance may well differ across sectors and countries, but will only be created by a government that accepts ultimate responsibility for the total emissions reductions.

The discussion points to various criteria that have to be evaluated when deciding on the application of a carbon price signal to sectors, and in particular when deciding on the timing of inclusion into a cap and trade scheme. The differences observed across different countries illustrate both the different emphasis given to the criteria, and the different economic and political situation of the jurisdictions.

4.2 Criteria to decide on regional coverage of cap and trade schemes

In the spirit of the previous analysis on sectoral coverage, the economic arguments relating to the regional coverage and the merits of creating a common cap and trade scheme for several countries and regions will now be discussed.

4.2.1 Static efficiency gains from large trading scheme

A larger trading scheme ensures that more investment and operation decisions are based on a common carbon price. If in contrast two regions are covered by separate cap and trade schemes, then equilibrium carbon prices might be higher in one of the regions. Firms and consumers are incentivised to make investment, operational and consumption choices which might only be viable at the high carbon cost and thus reflect utility losses or economic costs in the order of this high carbon price. At the same time, firms and consumers in the other region do not pursue low carbon choices that are viable at lower carbon prices. From a static perspective this is inefficient. Extending the regional coverage of a trading scheme can avoid this static inefficiency.

In addition, a larger emissions trading scheme involves more market participants. They are also more inclined to trade, because with a larger scheme they are more likely to find counterparts with different circumstances, preferences or information; thus a larger emissions trading scheme offers higher liquidity. Prices will vary less in response to changes to emissions at firm level or in relation to regional economic activities (Bell and Drexhage 2005). As more countries link up their schemes, the effect of political decisions in any one country in the scheme on prices will be reduced and the scheme could be less exposed to political uncertainty (Aldy, Baron et al. 2004). The market share of any one actor declines the bigger the market, therefore it also reduces concerns about exercise of market power.

4.2.2 Dynamic efficiency gains if some countries pursue more ambitious policies

Under the label of leadership an additional set of arguments is emerging in support of frameworks that enable countries to pursue ambitious climate policies that can also involve higher carbon prices in initially separate cap and trade schemes. If countries implement ambitious climate policies, then exploration and development of low-carbon societies will accelerate. Companies focus their management, research and financial resources on low-carbon solutions if the ambitious policy framework offers a prospective market.

The example of some ambitious countries can in turn: (i) enhance the political standing of groups in other countries who pursue socially responsible actions in their country ; (ii) facilitate the adoption of more ambitious objectives that have proven to be feasible; and (iii) accelerate emissions reductions in other countries, drawing on the behavioural examples, technologies and policy frameworks developed in early moving countries. [51]

Being an early mover in low-carbon policies might also offer economic benefits, like a reduction of import dependency on fossil fuels (Edenhofer and Lessmann 2005).

4.2.3 Alignment of cap and trade scheme with political responsibility

National governments have to pursue a wide set of policies including provision of information, regulation, market design and planning regimes in order to facilitate energy and carbon efficient investment, operation and consumption choices. The role that will be attributed to individual policy instruments is likely to be different across countries. Although some of the policies have already been successful, many studies suggest that large amounts of cost-effective energy efficiency and emissions reduction opportunities remain (see also figure 1.2). One reason that policies have not yet addressed this latent potential could be that governments have not set quantitative targets for policies that address non-marketplace barriers. It is, after all, difficult to define a metric classifying the barrier level. However, without metrics to measure the success of policies it is difficult to manage and improve the policies and to give their implementation sufficient priority.

Clearly defined national targets and milestones are therefore an important part of climate policy to facilitate implementation, benchmarking and execution of non-carbon price policies by governments. National targets and trajectories are receiving increasing emphasis in the EU Climate Package. Also EU Member States are increasingly using national emissions reduction targets to guide domestic policies. For example the Climate Change Bill discussed in the UK prescribes a trajectory and an independent Climate Change Committee to audit, not only whether the UK government is meeting past targets, but also whether the policies implemented by government can be expected to deliver the required emissions reductions.

As a cap and trade scheme is an important component of the policy mix, it would be desirable to align the boundaries of the scheme with the responsibility of the respective government. Following the discussion in chapter 3, this would also allow that the carbon price adjusts so as to help the government deliver its emissions target.

The European discussion illustrates the trade-offs that are involved. Assume emissions targets would be only defined at the European level, so as to be aligned with the cap of the European Union Emissions Trading scheme. In this case, there would be no monitoring and management of policies at country and sector level and the risk that policies are inefficient and watered down. Assume alternatively, that targets for transport emissions are allocated to the level of cities with no responsibility remaining at national or European levels. While cities can influence some parts of their traffic, they will struggle to negotiate fuel efficiency standards for cars. Thus this extreme version is not desirable either. The responsibility for emissions reductions will have to be shared across different administrative levels. This is a common procedure in financial budgeting of organisations and countries. The central level has responsibility for a balanced budget, and splits the budget into budgets for individual departments, which again are responsible for balancing their internal budget and are likely to further break down the budget.

The discussion illustrates benefits from aligning boundaries of cap and trade schemes with political responsibility. As the boundaries of the cap and trade scheme are extended, the mechanism of the scheme offers less support for national governments to deliver against targets defined at a national level and to monitor and manage policies that have to be pursued at the national level.

4.2.4 Alignment of emissions caps with domestic political support

Carbon pricing can only be implemented with public support. In particular, the level of ambition or stringency at which a carbon tax or cap and trade scheme is implemented cannot exceed the level of urgency perceived for the need to address climate change. Survey results depicted in figure 4.2 illustrate that this level of support varies significantly across both developed and developing countries. Further analysis would be required to verify whether the specific survey results are representative or what other methods could be applied to solicit the national level of support.

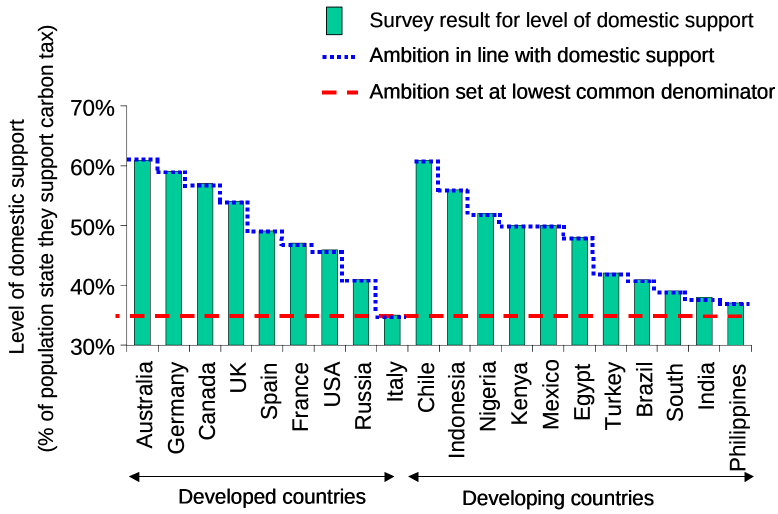

Figure 4.2 Extremes of setting climate policy targets: 22,182 total participants (BBC 2007).

The apparently large discrepancies raise the question whether countries will eventually pursue climate policy at the lowest common level, e.g. among developed countries, will negotiate some level of stringency that exceeds the ambition of individual countries, or will pursue climate policy at different levels of ambition and in line with the domestic support for the policy in different countries.

It is difficult to see how all countries would delay effective climate policies to be in line with the least ambitious country. However, this scenario is sometimes still depicted as a bargaining strategy. This is based on a game theoretical setting where it is assumed that countries only assess the damage of climate change for their own population and don't take responsibility for the impact of their own emissions on the livelihood of people outside of their country. In this case, assume country A commits that it will implement climate policy at the level of ambition of country B. This is an incentive for country B to implement a more ambitious climate policy, because the ambitious climate policy will also drive ambitious policies in country A and will thus have more benefits for the population of country B itself.

This framing of the negotiation situation is reflected in the decision of European heads of state in May 2007. European countries committed unilaterally to reducing CO_2 emissions by 20% relative to 1990 levels by 2020, and will increase the emissions reduction target to 30% relative to 1990 levels "provided that other developed countries commit themselves to comparable emissions reductions and economically more advanced developing countries commit themselves to contributing adequately according to their responsibilities and capabilities."[52]

It is not clear, however, whether the international negotiations on climate change are best framed as a bargaining situation. After all this would create incentives for all countries to delay action until a global deal has been reached so as to not lose their bargaining power. The early action problem that was discussed in chapter 2.4 at the installation level would be repeated at the level of countries. Governments might delay action and delay commitment to policies so as to reduce the emission reductions objectives they will have to deliver against after international negotiations. A first indication for a potential approach to future international negotiations on climate policy is emerging from the discussion of 27 European Member States. When their heads of state agreed in 2007 a European emission reduction and renewable target for 2020, the Euroepan Commission was asked to propose how this target could be shared across the Member states. Because of the large number of participating countries a very mechanistic approach was required to enable sharing of targets among the 27 Member States. It involved the economic model of the European Commission (PRIMES) and historic emissions and GDP values. Policies or commitments implemented by member states were not considered for the determination of national target. At least in this case any early commitments by national policy makers did not compromise their negotiation position.

The experience of the US delegation to Kyoto illustrates another difficulty that could follow if international negotiations are used to encourage individual countries to pursue ambitious climate policy beyond the level of domestic support. The US delegation, with support of the administration, negotiated an international agreement with somewhat ambitious targets, but subsequently failed to gain the support of the domestic policy makers necessary for ratification by Congress. To agree on a common level of ambition beyond the level of support that can be achieved in the national context, an agreement would have to involve side payments to gain the support of less ambitious countries. It might however be difficult to agree on such side payments among developed countries. They would not only be difficult to justify towards the population of the country that has to shoulder the burden, but would also set an undesirable precedent. Being less ambitious pays off. This suggests again that a common level of ambition which could be internationally agreed and subsequently domestically ratified is likely to be at the level of the least ambitious country.

The alternative to international negotiations on a common level of ambition of climate policy is an international agreement and unilateral commitments of countries to pursue climate policy at the level of ambition of their population. After all, an important driver for climate policy is a sense of responsibility. Countries may want to be seen to act in a socially responsible manner to reduce damage from climate change impacts caused by their emissions. If this results in political requests for ambitious domestic climate policies, then it is difficult for economists to explain why such ambition should be hampered just because other countries do not follow the same behaviour. The slave trade and later slavery was eventually abolished despite the "profitable trade" – not in a global action but initially country by country.[53]

Reality is likely to be somewhere between these two cases – international negotiations create an effective framework to encourage countries to discuss climate policy and can thus facilitate commitments to more ambitious climate policies than would have been pursued unilaterally. A sense of global 'fairness' can be supported by some level of international coordination. In a spirit of quid pro quo, countries are inclined to pursue more stringent policies if they expect that this will either induce other countries to follow, or if they mutually sign up for stringent policies.[54] An international context that addresses this concern is thus likely to support ambition in countries – even where the exact nature of ambition differs across countries. In addition, the dynamics of international processes can offer opportunities for domestic policies and to develop international objectives.[55]

If countries pursue climate policy at different levels of ambition, then more ambitious countries could pursue additional technology policies, infrastructure development and regulation and market design. They could continue to use the same cap and trade scheme and expose their industry and consumers to the same carbon price. However, to the extent that countries consider carbon prices as an important component of the policy package, more ambitious countries might also want to set tighter caps for their emissions trading schemes and thus create higher carbon prices. This would obviously only be possible with separate cap and trade schemes.

4.2.5 Implications of joint-up-schemes for future negotiations

Two fundamentally different perspectives are possible on international negotiations on climate policy. First, current emissions of a country are used as the reference level – and negotiations aim towards a common level of ambition of pursuing climate policy by all developed countries with special provisions for developing countries. Second, equal emissions budgets per head are used as a reference levels, and countries implement some trading scheme to allow countries with higher emissions levels to acquire some of these budgets while they are moving towards a similar emissions level.

Current discussions seem to be based on the first approach, while the second approach is reflected in concepts like contraction and convergence that envisage a gradual move towards equal per head emission budgets (GCI 1996), perhaps by 2050, and recently even received endorsement of the German chancellor Angela Merkel.[56]

As long as the focus of international discussions remains on the level ambition of emissions reduction, joining up emissions trading schemes of countries that are negotiating separately has a big drawback. It reduces the incentive for each country to aim for ambitious emissions reduction targets. Under a joint cap and trade scheme, industry in a country or region with more ambitious caps will buy allowances issued in the country or region. This creates large transfers to the less ambitious country. Anticipating these transfers, international negotiators will be not only judged by the level of ambition of the ‘global deal’, but also by the volume of transfers towards competing developed countries. Negotiators therefore have strong disincentives to agree to a deal that involves higher levels of ambition for their country than for other countries that are part of the same emissions trading scheme. A joint emissions trading scheme could thus reduce the level of ambition that can be achieved in future negotiations.

This is not to say that there is no role for emissions trading with possibly large transfers between developed countries. But this would be based on a situation where both countries initially commit to similar levels of ambition. Only later technical, economical, or climatic circumstances result in different abatement costs which are then arbitraged with emissions trading. This experience suggests that the European countries could move directly towards their envisaged 30% emissions reduction targets, if this is required to align economic policy with environmental consciousness.

This is also not to say that there is not an important role for international negotiations. The commitment provided by the international context is important to support domestic policy through the implementation process and can increase credibility towards investors.[57] For example, the rapid implementation of EU ETS was driven by the political – in this case not legal – commitment to the Kyoto protocol. Also the strong stance taken by the European Commission when deciding on the draft National Allocation Plans submitted by Member States for the second trading period was based on the provisions and target levels defined in the Kyoto protocol, as discussed in chapter 2.3.

Not only the implementation, but also the continued operation of a scheme requires public support. After all, a scheme that is in place is based on legislation that can be altered with new legislation. International agreements can provide some additional commitment to deliver emissions reductions and thus to continue the operation of a scheme. Although explicit enforcement mechanisms are difficult to implement in such agreements, international agreements do provide some outside commitment. A government that wants to deviate has to admit political failure and looses reputation and trustworthiness. On the domestic side, carbon pricing creates groups of investors and producers who need a continuing carbon price for their investment returns and market opportunities. They will create political momentum towards a continuation of a carbon pricing scheme.

4.3 Creating global linkages

Several cap and trade schemes are evolving globally and envisage obligatory participation of covered emitters. Australia and New Zealand are developing cap and trade schemes and the Regional Green House Gas Initiative (RGGI) covers power generation among states in the North-East of the USA. The Western Climate Initiative including 6 USA states and 2 Canadian provinces is analysing and discussing scale, scope and specifications of a cap and trade scheme. In addition to these government-led programs that will be obligatory for emitters covered by the schemes, several schemes offer individuals or companies opportunities to off-set emissions or trade deviations between emissions and base-line emissions.[58] Figure 4.4 illustrates three main channels that are discussed for linking up the different schemes.

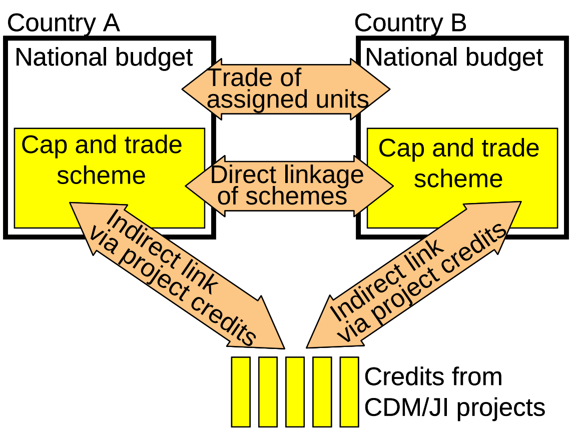

Figure 4.4 Three main channels for linkage between countries

4.3.1 Direct linking of cap and trade schemes

If schemes are linked directly, then market participants can buy allowances in either scheme to cover their emissions. Assume the Australian scheme and EU ETS are directly linked, and the Australian carbon price is lower than the European price. A European emitter can buy 'cheap' allowances in Australia to cover its emissions. This will reduce the allowances available for Australian emitters, and one additional emissions reduction has to be implemented in Australia albeit at lower cost than in Europe and supported by the financial transfer from Europe to Australia. Emitters and traders will arbitrage both markets such that at the end the carbon allowance price in Australia equals the European price. High cost emissions reductions in Europe are avoided and replaced by lower cost emissions reductions in Australia. This efficiency improvement is the main reason that is usually quoted for linking up schemes.

4.3.2 Trade of assigned units

The Kyoto protocol allows countries that have adopted explicit caps to trade the emissions quantity warranted by the cap – their 'assigned units'. The protocol also outlines the CDM and JI mechanism to allow for trading of emissions reductions at the project level.[59]

Trade of assigned units typically focuses on the sale of units not required to cover domestic emissions of Russia, Ukraine and Belarus, (their 'hot air'), which have emissions caps that are significantly higher than expected emissions. Thus the respective governments can sell assigned units to governments of other countries. The volume and timing of such trades is highly uncertain as buyers might withhold assigned units to increase their price, while several potential buying countries declared that they would only buy assigned units if sellers would use the money in sectors where it would contribute to emissions reductions (greening of assigned units). To prevent this uncertainty from spilling into EU ETS, the European Directive on Emissions Trading prevents governments from exchanging assigned units into EU ETS allowances.

Linking will make sense once emissions budgets are determined internationally, perhaps eventually on a per head basis. Linking will allow the allocation process to focus on equity issues and ensures the economic efficiency of trading. International political discussions and support for an allocation based on a per head basis currently relate to the 2050 horizon. In contrast, discussions of 2020 targets usually centre on the level of ambition that would be required by a country to achieve emissions reduction targets – and the objective seems to be to find targets that require a similar level of ambition across countries.

4.3.3 Indirect linking

Linking of schemes via the project mechanisms CDM and JI already exists. As several emerging cap and trade schemes allow their emitters to use project credits to cover their emissions, emitters in different schemes will compete for these project credits in developing countries.

Currently the largest demand come originates in Europe and Japan. Although currently the dominant Japanese policy for industrial sectors is referred to as 'voluntary agreements', the framework is more stringent than implied by the name. Not only are the efforts monitored, reported and discussed on an annual basis, but in sectors that failed to meet their emissions targets, like steel and power, the sectoral targets were broken down to a company level. Companies are then responsible for buying CDM credits to cover their excess emissions.

With the demand from different countries, credits will go to the trading scheme with the highest carbon prices thus reducing scarcity and carbon price in that scheme. This link can over time lead to an equalisation of global carbon prices, provided the global CDM and JI markets become sufficiently large, continues actively post-2012 (see discussion in preceding section), and the constraints of countries on the use of CDM credits in their domestic schemes (supplementarity criteria) is not binding.

One concern arising from such indirect linking relates to the criteria and definition of projects that are qualified to create CDM credits. All project credits to be used under the Kyoto protocol have to be certified by the executive board of the CDM. As the USA has not signed up to the agreement, the design of US schemes might involve different definitions of project credits. Imagine emitters under the Regional Green House Gas Initiative (RGGI) investing in projects that are certified or can qualify under the Kyoto criteria. RGGI then relaxes the criteria and also certifies some additional project types or defines the ‘additionality criterium’ of the projects less rigorously, thus potentially allowing for cheaper projects. Emitters covered by RGGI will sell their previous CDM project credits to emitters in countries that do not offer the lenient new standard and acquire the new and cheaper credits instead. The change of definition under RGGI will result in an inflation of available credits and could contribute to volatility in other schemes. Ironically, the very existence of these other schemes created the political environment that might have enabled this change of definition. If the other schemes did not exist, RGGI emitters owning ‘expensive’ CDM projects would be exposed to a larger devaluation of their projects under a relaxed standard and would be more likely to oppose the change. This illustrates the importance of international coordination of the definition of project credits.

4.3.4 The politics of linking

Linking is politically an attractive option – offering the opportunity to mirror political links in economic instruments. Usually a direct linking of schemes is envisaged, e.g. allowing emitters of the Western Climate Initiative to cover their emissions with European allowances and vice versa as envisaged by the International Carbon Action Partnership (ICAP 2007). Such linking effectively integrates the cap and trade schemes of two jurisdictions. Section 4.2 discussed the various benefits and drawbacks that would result from such an integrated scheme.

From a political perspective linking two schemes can offer an additional benefit – creating a clear compliance mechanism. If two schemes are linked, then market participants will buy allowances in the other country if the domestic emissions target is exceeded. This transfer creates the penalty for a country that failed to implement the necessary domestic policy and actions.

But linking of schemes also creates a risk. If policy makers in one country are not prepared to pay the penalty for non-compliance, and do not want their industry to acquire allowances in the linked country, they might abandon their domestic emissions trading scheme including the link to the other country. Concerns that policy makers might abandon their scheme would not only jeopardise investment decisions in the affected country, but also have implications for the linked countries. Should the scheme be abandoned then a broken link would reduce demand for allowances and result in lower allowance prices. Risks of lower allowance prices again complicate investment decisions.

Linking markets also creates the risk that individual countries only consider the impact of their actions on domestic industry and consumers and ignore the impact of their decisions in linked countries. This was illustrated in chapter 2 with the experience of the design of National Allocation Plans under EU ETS. Member States were happy to allocate excessive allowances to their domestic industry, and they were not concerned about their 'little' domestic over-allocation. The European scheme was only saved by the resolute intervention of the European Commission demanding cut backs for the National Allocation Plans. The lesson for linking might be that schemes can only be linked where free-riding on the scarcity created by other countries can be avoided. Credible commitments to emissions targets that create binding caps in the participating countries are thus a prerequisite.

Monetary policy experience suggests a second approach towards linking markets. Most European countries 'linked' their currencies to form the Euro and were concerned that individual countries would free-ride on the monetary stability provided by the others. Hence all participating countries agreed on a set of criteria for their fiscal policies. [60] Enforcement of the criteria has proven difficult and has only been achieved in a broad sense, but so far sufficiently well to ensure a robust currency. It is difficult to say whether the Maastricht criteria and bilateral negotiations would have sufficed to deliver this outcome. After all, the joint membership in the European Union provided additional authority and leverage to encourage compliance.

The benefit of linking thus seems to be a question of time-frames. It could be a core component of a long-term solution of allocating global carbon budgets but is not appropriate for ambitious initial steps. This suggests, even where strong links are initially not desired, that it is important to ensure that the design of national policies is ready for future linking. Given the long-term need to link up schemes, short-term political ambition could prove to be a valuable means of ensuring early compatibility of the schemes. Even where it does not result in direct and immediate linking of schemes, it will avoid the need for future harmonisation. Such harmonisation will be difficult once schemes are in place because changes will create winners and losers and thus a potential for political opposition. In the long term, linking schemes could create a mechanism that allows developed countries to support emissions reduction measures in developing countries and thus find the least cost mitigation solution. [61] The implied transfers might be an important component of cooperation between developed and developing countries. The next section discusses in more detail the different options for such engagement.

4.4 Reaching out to developing countries

This section discusses how our interaction with developing countries can evolve to deal with newly emerging challenges. First, the scale of emissions in developing countries is rising, as illustrated in figure 4.2. They are expected to account for about two fifths of global CO_2 emissions by 2010. [62] Second, the experience from the first years of climate policy suggests that it is important to pursue domestic policies including carbon pricing. Third, differences in economic strength and institutional settings amongst developing countries are increasing and need to be addressed in the mechanism design. For example almost no CDM projects are implemented in the least developed countries.

Any approaches to engage with developing countries has to has to reflect the fact that developing countries still have lower emissions levels per head, and less historic emissions and thus less responsibility for climate change. They also have fewer resources available to finance measures to pursue emissions reductions and other pressing priorities. During the Kyoto negotiations, therefore, only developed countries contributed to emissions reduction targets.

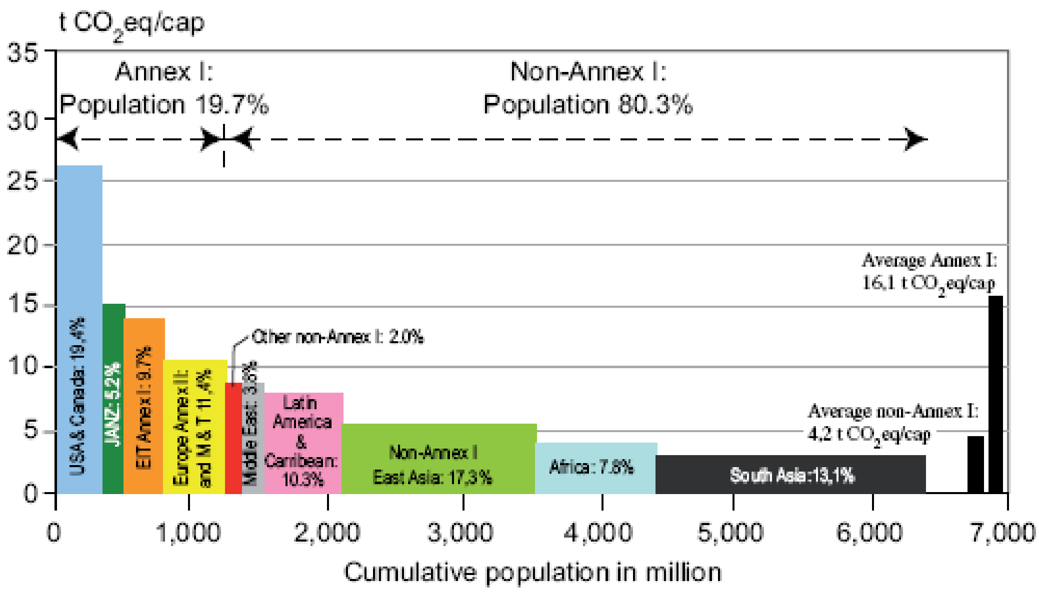

Figure 4.2 Distribution of regional per capita green house gas emissions in 2004. (IPCC 2007).

The Clean Development Mechanism (CDM) was then created to allow for financial flows from developed to developing countries to finance low carbon projects, technology transfer and support sustainable development. [63] As of November 2007 there were 850 registered CDM projects (India hosts 34%, Brazil 13%, Mexico 11% and China 16%, with the other 26% spread around the world). The UK has the highest number of registered CDM projects with 41% of all the projects. The CDM projects registered by the end of 2007 are expected to deliver more than 200 million tonnes of CO_2 equivalent emissions reductions per year during the first commitment period.[64] Thus the volume of expected certified emissions reductions (CERs) that will be available for the period 2008-2012 was 1.08 billion, with more than a further billion CERs associated with projects in the pipeline[65].

The first evaluations suggest that the mechanism has been successful in supporting individual projects, establishing the use of some low carbon technologies, creating local stakeholders for climate policy in developing countries, and demonstrating some commitment by developed countries to support developing countries (Castro and Michaelowa 2008).

The European Commission has proposed in the draft Directive of January 2008 to strictly limit the use of CDM credits post-2012 and to re-evaluate this limit when Europe increases its emissions reduction targets from 20% to 30% in the context of an effective international agreement.[66] This offers the opportunity for an open discussion on the mechanisms to facilitate international cooperation on climate policy. A multitude of variations are analysed in literature.[67]

Table 4.1 summarises three basic approaches that are currently discussed. First, the Clean Development Mechanism targets the funding to individual projects. Second, with policy CDM and no-lose targets, central governments of a developing country are paid for the emissions reductions they encourage with a set of domestic policies. Third, in the case of policy cooperation transfers are no longer directly linked to emission reductions, but are part of the cooperation to pursue domestic policy frameworks that facilitate low carbon consumption and investment choices and a wider transformation. The funding can again be directed to central governments or used in other sectors to support e.g. the rural development of a country.

	Recipient of transfer			Strength of approach				
	Projects	Central gov.	Other sectors	Specific volumes	Limited rents	'Simple' govern.	Support policies	Clear metric
CDM and sectoral CDM	X					X		X
Policy CDM and no-lose targets		X					X	X
Policy cooperation		X	X	X	X		X	

Table 4.1 Some policy options to engage developing countries and their evaluation

4.4.1 Criteria to evaluate policy mechanism

Table 4.1 also summarises five criteria that can be used to evaluate the different mechanisms to engage with developing countries. They are now discussed in more detail.

Criterion 1 – Allow for specified volumes

The total costs of emissions reductions in developing countries, and thus the scale of the transfers, will be significant. Figure 4.3 approximates the volume of possible emissions reductions for different carbon prices based on the recent IPCC report. Assuming all emissions reductions could be realised, this would allow for about 8 billion tonnes of emissions reductions at a price of 20 $/tCO_2$ and would require annual payments of $160 billion. Another measure of the scale can be derived from a recent projection of the International Energy Agency. In the period up to 2030, half of global energy sector investment is expected in developing countries.[68]

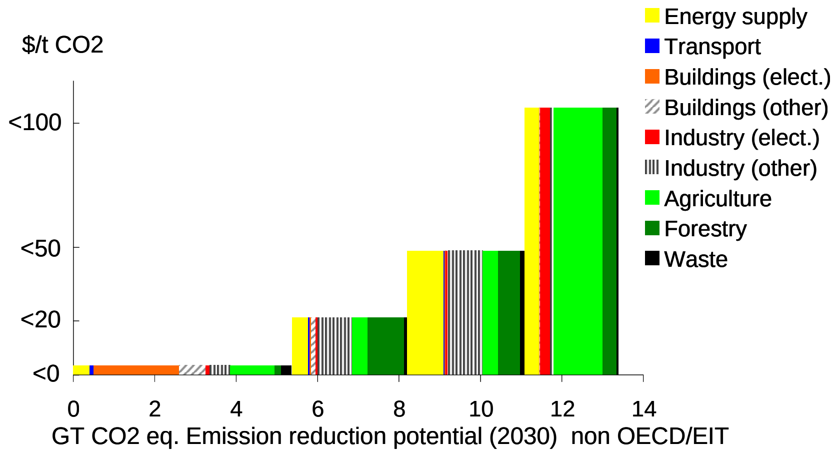

Figure 4.3 Economic potential for GHG emissions reductions in non OECD, non IET countries relative to base line emissions SRES B2 (IPCC 2007).

Given the scale of these flows, they will have a significant impact on budgets. Policy makers in developing countries will require some stability of financial flows so as to be able to use the funding to pay for projects or staff costs. Likewise, policy makers in developed countries have to be able to plan for the required flows, for example in order to make the necessary tax or CO_2 auction revenues available.

There is a need for stability, even when the funding is directly provided by private sector agents that finance low carbon projects in developing countries. After all, the private sector only pursues the investment in exchange for certified emissions reductions that can be used in the emissions trading schemes of developed countries. The discussion of investment security in chapter 3 showed that investors in developed countries require clarity about the volume of emissions reduction credits that enter their emissions trading scheme to be able to project the emissions reductions that have to be pursued domestically. Hence even in the case of private sector investors, the mechanisms to engage developing countries should allow for some specification of the volume of transfer towards developing countries.

Criterion 2 – Avoid large transfers of rents

If each unit of emissions reduction is paid the same carbon price, then the required transfer volume can be a multiple of the real costs incurred by the low-carbon efforts. Figure 4.3

illustrates the differing costs per ton of CO_2 for different measures that reduce carbon emissions. If all emission reductions receive the same carbon price, then developers of lower cost projects, or the countries where the projects are hosted, can capture the rents between the carbon price and cost. On average these rents are likely to be bigger than the additional project costs.[69] While rents create economic incentives and can accelerate the decarbonisation process, the scale of the rents involved could undermine the political support of the mechanism in developed countries.

The design of policies to limit rent transfers is a fundamental challenge for carbon pricing. Section 1.2.3 already discussed the distributional impacts of carbon pricing within a country, and emphasised the need to consider these implications when discussing the recycling of carbon tax and auction revenues. Such recycling is difficult to envisage in the international context. However, one option could be to 'recycle' rents to pay for adaptation measures.

Criterion 3 – Compatible with governance structures

Every recipient country will be in principle pleased to receive transfers. However, the experience of many oil and other resource exporting countries points to the potential risks. In many instances they have resulted in bad governance practices, an increase of inequality and consumption preventing wider economic development. Transfer payments to engage developing countries in ambitious climate policy have to be carefully designed, and they have to be additional to existing and promised transfers under development assistance.

The scheme also has to be designed so as to maintain support in developed countries for the continuation of funding streams. This requires at the side of developed countries a clear commitment, perhaps by hypothecating some of the revenues from CO_2 allowance auctions or by ensuring a certain volume of certified emissions reductions from developing countries can be used in domestic trading schemes. The continued political support of such transfers will also require a demonstrable success of the decarbonisation policy and transparent use of the transferred money to fund emissions reductions or other shared policy objectives like development, education or health.

Criterion 4 – Support domestic energy efficiency and low carbon policies

Effective climate policy requires that local policies contribute towards a lower carbon objective. Currently, many developing countries subsidise energy, which makes energy efficiency measures less profitable, and contributes to higher energy consumption and carbon emissions. It is expensive and inefficient to use project based approaches to subsidise low-carbon technologies against prevailing price signals and regulatory structures. Mechanisms to engage developing countries could offer support for domestic policy development and perhaps compensate for the political effort and real costs incurred when implementing these policies.

The experience of the European Union Emissions Trading Scheme discussed in chapter 2.3 also illustrates the value of commitment by European governments to the Kyoto protocol.

This provided time frames and target levels for the domestic implementation. Perhaps mechanisms to cooperate with emerging economies can also be designed to offer similar support.

Criterion 5 – A clear metric

Monitoring and reporting of policies and projects and the effective management of the cooperation depends on a transparent metric to measure the success. Verified emissions reductions of the project based approach offer such a metric. It is not clear whether they can be translated for the evaluation of domestic climate policies. One concern is the time-lag between the implementation of a policy package, private sector investment response and final emissions from the operation of the new infrastructure. Would policy makers, particularly in a developing country, pursue policies where their main benefit in terms of financial transfers will only materialise with a time-lag of five to ten years?

To reduce the time-lag, transfers can be awarded based on lead indicators for the success of such policies (text box four). Such lead-indicators, or intermediate output metrics, could respond to changes to the regulatory framework, changes of relative energy and carbon prices or responses of individual investors. International frameworks for climate cooperation will have to find some balance between the transparency created by output based indicators measuring emissions and quicker response that intermediate output based metrics offer that measure the implementation of policies or their initial success.

4.4.2 Clean Development Mechanism

The mechanism creates incentives for private sector agents to propose methodologies, initiate projects, and negotiate planning and regulation within the local and national administrations. This created a dynamic that would have been difficult to envisage without private sector participation. The strength of the CDM mechanism is the transparent governance structure linked to a clearly defined metric. The CDM executive committee is responsible for accreditation of projects and monitoring of delivered emissions reductions. Despite individual concerns about the verification mechanism, the large majority of projects have delivered real emissions reductions in the countries where they are implemented.

Thus the CDM mechanism has created a source of transfer that is not directly linked to the budgets of national governments in developed countries, and is thus likely to be easier to agree in international political processes and better protected from short-term political volatility.

The CDM mechanism established a global price for certified emissions reductions which is paid for all emissions reductions, irrespective of the incurred costs for the emissions reduction. Adjustments to the price only reflect the project, country and other risk components. Thus the mechanism creates large rents that are shared by domestic industry in developing countries and project developers. Sometimes the countries hosting the projects impose export taxes on project credits to capture some of the rent.

Text box 4: Output based metrics (emissions reductions) versus policy targets

Metrics to define policy targets have been developed in many policy fields. In Poverty Reduction Strategy Papers (PRSP) least developed countries negotiate with the World Bank policy improvements for a three year horizon. If they deliver policy objectives, some of their debts are relieved (Coudouel et al. 2002). In Local Public Service agreements (LPSA) local authorities discuss with the UK central government areas of policy improvement, and receive funding if they deliver against policy metrics in a three year horizon (DTLR 2001).

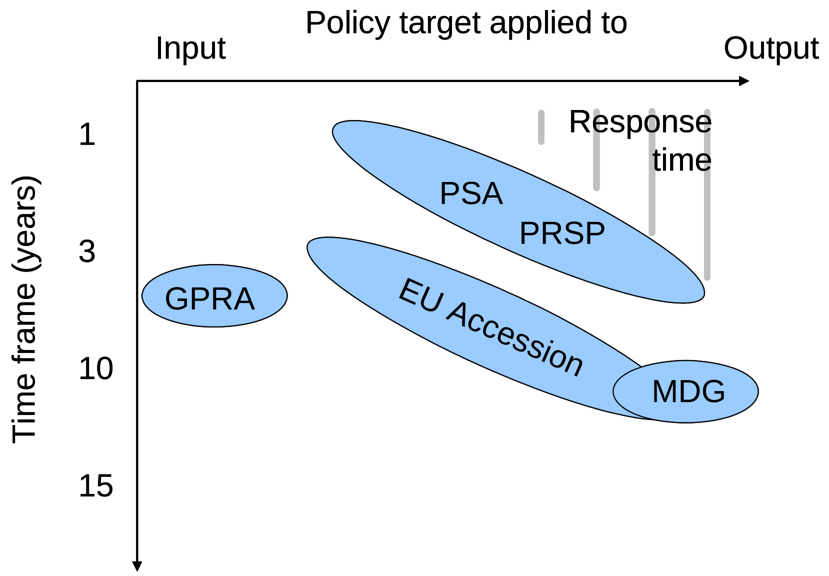

Figure 4.4 Time frames used for the definition of policy targets – and differentiation between input based and output based metrics(Neuhoff and Lester forthcoming).

Figure 4.4 also lists experiences with Government Performance Results Act targets for central administration in the USA (US Senate 1993), the accession process of new member states to the European Union, and the Millennium Development Goals scheme (Black and White 2004).

The horizontal axis shows that in most cases it is not the final output to which the policy targets apply, but the successful implementation of policies, or delivery of intermediate outputs, which are measured. The vertical axis depicts time-frames over which the policy targets are defined. With shorter time frames, output based metrics can not be used, and policy targets use intermediate output metrics.

Several reasons can contribute to the use of intermediate output based metrics.

- they allow for shorter time frames in line with political time-horizons (elections)
- with shorter time frames, learning from initial experiences can be used to quickly improve the structure and implementation of policy cooperation
- it is difficult to predict emission reductions from transformational change and to attribute these to specific policies.

Experience suggests that successful metrics are appropriate, relevant, selective, simplified, capturing cross-cutting outcomes. Actors have to be confident that policy targets are achievable to pursue the necessary activities.

A second draw-back of the mechanism is that it pays on a project by project basis the additional costs for a low-carbon technology relative to the conventional technology. It subsidises investments in energy and carbon intensive sectors and in the process also allocates some of the above mentioned rents to these sectors. This will increase activities and reduce product prices from these sectors and can result in higher demand for carbon intensive products and services. It creates no incentive for host countries to implement domestic policies and to encourage low-carbon investment, operational and consumption choices. On the contrary, host countries and their industry sectors might delay the implementation of domestic policies: if domestic polices suffice to finance low-carbon projects then the projects are precluded from qualifying as CDM project.

Finally, it is frequently expected that carbon prices in Europe will have to rise above 40 Euro/t CO_2 to deliver the necessary emissions reductions in Europe. At this price level the CDM project volume, and transfer payment, might well exceed the politically acceptable in major developed countries. Developed countries would in response impose quantitative limits on the use of CDM credits, and thus create uncertainty about the value of CDM project credits and complicate the use revenues from sales to finance low-carbon projects.

The project based approach requires international accreditation, monitoring and verification of the projects and creates significant transaction costs and thus restricts the applicability for small projects. To circumvent this problem it is often discussed to allow sets of projects within a sector to be jointly evaluated (Sterk and Wittneben 2005).

In summary, the CDM has delivered several benefits, including an institutional framework for tangible cooperation on climate policy with developing countries. But it is not well suited to serve as the main mechanism for engaging developing countries post-2012 because of the large rents involved and the subsidies it provides to energy intensive sectors. These reduce the incentive to move to lower carbon industrial structures and fail to encourage low carbon policy frameworks. The main strength of the CDM is the incentives it creates for private sector agents to investigate new technologies and pursue project types in countries where they have not been explored before. These pilot projects are important to adapt the technology to regional, cultural and regulatory specificities and can subsequently serve as a demonstration for their viability. They can thus facilitate the implementation of domestic policies for their large scale application. By focusing on first of kind projects in different countries, the CDM mechanism might continue to play an important role for international climate policy.

4.4.3 Policy CDM and no-lose targets

Several proposals suggest expanding the scope of the CDM mechanism beyond the implementation of projects to also support the implementation of domestic climate policies in developing countries.[70] Building on the experience of the CDM, an international body would judge the emissions reductions that can be attributed to a set of policies which are applied to a sector, and the host country would be awarded the corresponding volume of certified emissions reductions.

The approach facilitates the implementation of domestic climate policies in developing countries, and in theory retains a clear metric for the measurement of delivered emissions reductions. In practice the emissions reductions are calculated by comparing realised emissions against some counterfactual. Over time the choice of counterfactuals would become more complex, and thus the transparency and credibility of the approach will decline.

The volume of transfers continues to be linked to the volume of emissions reductions that are paid at the price of certified emissions reductions. This creates the challenge both for developed and developing countries of uncertainty of revenue flows, related both to the market based price of certified emissions reductions and to the volume of these flows. In addition, as all the emissions reductions are paid for at the same price, significant volumes of rent transfers can be expected.

The concept of 'no-lose targets' is receiving increasing attention. Developing and developed countries negotiate a target for a developing country (Philibert 2000), or a sector of the country (Bosi and Ellis 2005). If the target is missed nothing happens; if the target is exceeded, the country can sell the emissions reductions beyond the agreed target to developed countries. Revenue from these credits creates an incentive for developing countries to implement effective national policies to reduce carbon emissions.[71] The approach again has the benefit of clearly defined metrics, and incentives for the domestic implementation of climate policies. Three challenges will have to be addressed for a successful implementation.

The first challenge relates to the definition of the recipient. European countries are currently reluctant to buy assigned units under the Kyoto framework from Russia. Will they be prepared to pay central governments of 'rising powers' like China, India or Brazil for emissions reductions?

The second challenge for all parties involved is the uncertainty about the future transfer volumes. For example the IEA World Energy Outlook projects annual emissions growth rates for China between 3.3% in the reference scenario and 2.3% in the alternative policy scenario (IEA 2007). Assuming a slightly bigger variation, e.g. between 2% to 3.5% results in an uncertainty about total emissions in 2020 of 1.7 GT. This exceeds the total volume of emissions that are expected from installations under the European Union Emissions Trading Scheme in 2020.

The third challenge relates to the uncertainty as to whether the incentive will be binding. If the no-lose target is negotiated with favourable terms for the developing country, then it creates large transfers with significant rents captured for low-cost emissions reductions. If this is not politically acceptable in developed countries, then no-lose targets have to be defined more ambitiously so as to limit this transfer volume. But more ambitious no-lose targets might not be met, e.g. if economic growth is unexpectedly strong or domestic policy implementation is slow. As soon as it becomes apparent that the target cannot be delivered, the incentives for emissions reductions are lost. If the no-lose target is translated into domestic policies to support low-carbon private sector investment, already the perceived risk of such changes can negatively impact investments (see chapter 3).

4.4.4 Policy based cooperation

Given the challenges with the measurement of base lines, uncertain revenue streams and rent transfers, there is merit in exploring options for cooperation that are not directly linked to the volume of emission reductions and do not directly apply a carbon price. Instead they could be related to the real costs incurred in developing countries with the implementation of specific policy measures. This could build on positive experiences of developing countries and the World Bank with schemes such as the Poverty Reduction Strategy Papers (Coudouel, Hentschel et al. 2002) or the Public Service Agreements the UK government has signed with local authorities (Black and White 2004). Both approaches start with a negotiation of policies packages that are pursued and metrics to assess policy success. The World Bank and the British Government have made funds available to support some of the costs of the policy implementation. If the agreed targets are delivered, then additional funds are made available, either annually or at the end of the three year period.

For developing countries the attraction of such policy based cooperation is receiving early payments to support policy implementation and successful execution. The close link between climate and energy policy also suggests that developing countries can benefit if, for example, climate policy increases energy efficiency and reduces energy import dependency.[72] Providing additional incentives or support for the implementation of climate policy might accelerate the implementation or increase the stringency of policies. The framework can also increase the stability of funding flows, which makes them more suitable to finance projects and costs for the policy implementation. A very transparent process has to be developed, however, to ensure that the negotiation of policies, metrics and targets fairly reflects the interests of the involved countries.

For developed countries the attraction of this approach is that the required funding streams can be predicted and are directly linked to specific costs associated with the climate policies with, at least in theory, only small rent transfers. As payments are not directly linked to the final emissions reductions, however, governance arrangements have to be developed for effective negotiation, monitoring and verification of cooperation agreements. After all, governments in developed countries are accountable towards their citizens for the use of tax money or auction revenues.

A term that is widely used in international discussions on climate policy is ‘sectoral agreement’. So far there is no unique definition of the participation, purpose, stringency and governance arrangements. [73] If politically desired, a sectoral agreement could offer a framework to pursue policy based cooperation. Such a framework could enable third party monitoring and verification of agreements and provide guidelines for their negotiation.

The discussion of the three mechanisms illustrates that all of the approaches face some challenges. The cooperation between developing and developed countries is likely to evolve beyond the CDM mechanism and will thus involve new approaches that are tailored according to the capabilities and needs of different groups of developing countries. They will encourage the implementation of stringent carbon policies, and preferably would also include a carbon price.[74] Careful design and implementation will be required to address specific weaknesses. The mechanisms ultimately implemented might well be a hybrid – tailored for the needs of different developing countries.

4.5 Conclusion

The chapter began by asking the question whether carbon pricing schemes should be applied simultaneously to all sectors of an economy. The first instinct of economists and traders is to argue for an integrated scheme with one carbon price that allows the market to select the least cost mitigation options. However, other considerations are relevant. Across sectors the level of demand response and innovation triggered by carbon prices differs. The equity implications of costs faced by different consumer segments also varies. In addition pre-existing tax schemes, such as fuel taxes in the transport sector, are often at a far higher level than current carbon prices, which would not materially affect demand at the low level of current carbon prices. The smaller scale of emitters would create significant transaction costs, and would likely require an upstream approach that makes distributors or importers of fossil fuels responsible for the emissions. The diverse set of factors to be considered suggests that the timing for the inclusion of different sectors might depend on the specific circumstances of a country.

Should these different national schemes be merged? Emissions allowances can in principle be traded across countries and thus create a global market with a common carbon price. Again economists' and traders' first response is typically in favour of such a market, as it would enable firms to target the lowest cost mitigation opportunities.

This discussion often overlooks the fact that carbon pricing remains a policy instrument that is implemented by, and requires the continued support of, national governments. The level of awareness and public support for climate change differs across countries. This creates two basic options. First, international negotiations could agree on a common level of ambition in determining national emissions reduction targets. The level of ambition that would result in this case would likely be close to the lowest level of ambition of any participating country. This was demonstrated in the case of Kyoto when an attempt to be more ambitious failed. US domestic policy makers did not ratify the protocol negotiated by their delegation. The second option is that governments commit to emissions reduction targets at different levels of ambition reflecting the level of domestic support for climate policy. Again the international framework is important as it provides both a mechanism for commitment and the reassurance that other countries will eventually follow and possibly even provide future leadership.

There are implications of both alternatives for cap and trade schemes in developed countries. If countries pursue climate policy at similar levels of ambition, then carbon prices in the respective trading schemes are likely to be similar and do not create significant financial transfers between countries. Over time unexpected economic growth, surprising weather conditions, or as in the case of Japan the long-lasting outages of several nuclear power stations, might produce additional emissions and thus more scarcity for allowances in a country. A joint carbon market has the benefit of additional flexibility to respond to such unforeseen situations. These unexpected shocks would create financial transfers – but they are likely to be more acceptable where all parties benefit from the flexibility. However, when countries pursue climate policies with different levels of ambition, then the carbon price in an ambitious country would initially be high. Under carbon trading firms in ambitious countries with initially high carbon prices would buy allowances in other countries, either from governments or from firms. This would eventually equalise the carbon price. These financial transfers are potentially large and their anticipation creates incentives for countries not to commit and implement a tight cap for their trading scheme. Trading allowances among developed countries might thus be only viable once they have converged to a similar level of ambition in their climate policy.

This does not imply that countries should not pursue high carbon price levels or ambitious climate policies. Higher price levels will accelerate the development of lower-carbon technologies, infrastructure and institutional solutions and allow firms to become early movers across a set of technologies and service solutions. Climate policy can also deliver co-benefits, such as reduced import dependency on fossil fuels so limiting exposure to international fuel price volatility. Successful examples of de-carbonisation can facilitate repetition in other countries and provide support for interest groups that call for more ambitious policies in other countries. Eventually, the levels of ambition might converge and allow for linking of the schemes, perhaps by 2020. Once the necessary low-carbon technologies are developed and available at large scale and decent costs, then the focus can shift from dynamic economic efficiency with its emphasis on technology and infrastructure development, towards static economic efficiency with attention concentrated on least cost projects. Future linking of schemes can be facilitated if their main features are already harmonised today. This avoids uncertainties about future changes and contributes to a stable investment framework.

Developing countries are part of any solution to climate change. In response to growing emissions and threats from the impacts of climate change, there is both a need and a motivation to participate in active climate policy. Currently CDM represents the main channel for financial transfers from developed countries. This mechanism has delivered projects across a range of countries and technologies, and has created stakeholders in developing countries with an interest in, and experience of, climate policy.

CDM projects are initiated cooperation between developed and developing countries on climate policy. Expanding the scale and scope of CDM is often discussed, but probably also some of the fundamental aspects of the mechanism will evolve. The financial transfers that would be required to finance low-carbon projects against prevailing energy subsidies and without complementing domestic policies would be too large for comfort. In addition, while a common carbon price is economically efficient, it results in large rent transfers to project developers, carbon intensive sectors or governments of host countries. This inflates the required funding stream from developed countries and might undermine political support.

Rather than starting top down with the specification of emissions targets, international cooperation could provide the means to pursue individual sets of policies and provide the necessary funding streams. Like developed countries, developing countries will be more effective in increasing energy and carbon-efficiency if they pursue the necessary domestic policies, including putting a price on carbon. This is more challenging in the context of developing countries with different priorities and potentially stronger equity implications from carbon pricing. The challenge for international processes will be to find means of supporting developing countries in their implementation of domestic climate policies.

The discussion suggests that carbon pricing might be applied at different levels across countries and sectors during the first few years of implementation. Thus both the political process of pursuing more ambitious targets, and the evolution of societies and technologies towards creating a less carbon-intensive world, might be accelerated. But, this raises questions about whether such a vision is compatible with a world with close trade links across countries and continents. Will carbon price differentials result in relocation of production rather than improvement of carbon-efficiency?

5 A world of different carbon prices

Key points:

- *Leadership in ambitious climate policies, including higher carbon prices, is possible.*
- *This requires carbon pricing policies that are robust to such price differences.*
  - *For 98-99% of economic activities this creates no concern about leakage.*
  - *For only a few carbon intensive commodities is leakage a concern.*
- *Viable policy instruments exist to address leakage - but have negative side effects.*
- *We need to explore internationally the most suitable solution for each commodity.*

The previous chapter argued that countries and regions might pursue climate policies at different levels of ambition. This would likely include different carbon prices for a transition period, perhaps up to 2020. Now we will assess the implications of different carbon prices in countries connected by international trade. There are important opportunities and difficulties to consider. The opportunities lie in the first mover advantages afforded to countries that support the development of low-carbon products and technologies. Just as Denmark's wind technologies have been established in world markets, new market leaders will emerge for other products.

But there is also some concern, that regions with high carbon price levels could risk inducing industry to alter investment, production and closure decisions about plants, and thus move carbon-intensive production towards countries with lower or no carbon prices. This would have three implications that might have to be addressed by the design of the policy instrument and complementing measures:

- Shifting of production in response to a more stringent emission cap and associated policy to a country without a stringent cap creates carbon leakage. The freed up allowances in the first country will be used by other sectors that reduce their efforts in emission reductions. Whenever some of the shifted production is not covered by a stringent national cap it will increase emissions in the new country and thus contribute to a global emissions increase.

- Companies may limit passing through carbon prices to product prices either to protect current market shares and hence delay relocation, or in response to output based allocation of allowances. This dampens carbon price signals for carbon-intensive commodities and services, reducing the economic incentive to substitute towards lower carbon alternatives.

- Countries that pursue a more stringent carbon policy might put jobs and tax revenue at risk from relocation. Where such concerns are substantiated for specific sectors or effectively communicated as big concern in the political process, they might limit the interest of government to pursue ambitious climate policies.

Text box 5: Leakage channels

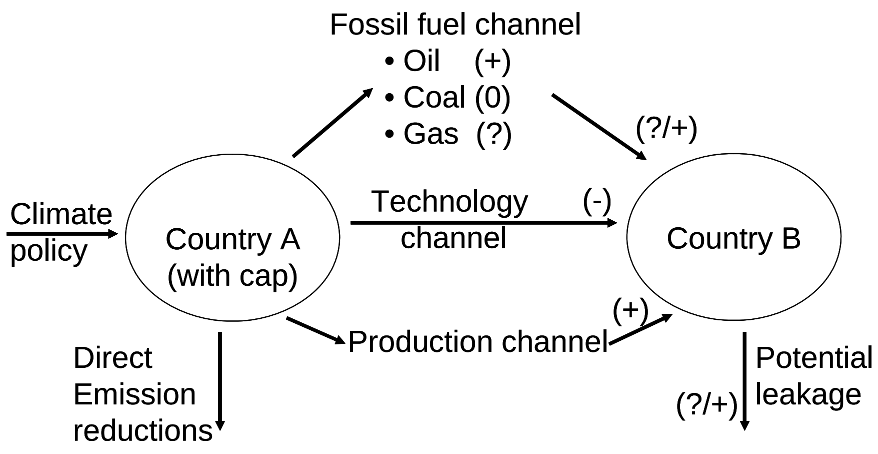

Figure 5.0a: Potential channels for leakage

The Intergovernmental Panel on Climate Change defines leakage broadly as “the emission increase abroad caused by unilateral climate policy measures at home.”(IPCC 2007) and identifies three channels (figure 5.0a). Macroeconomic models estimate that, if unmitigated, they could together increase emissions by 0.05 to 0.2 ton CO_2 in regions not covered by climate policy for every ton of CO_2 emission reduces in countries with climate policy (IPCC 2007).

Fossil fuel channel: (Felder and Rutherford 1993) If demand for **oil** decreases due to climate policy, then this could reduce oil prices. In response demand for oil and therefore emissions could increase in other regions. If demand for **coal** decreases due to climate policy then this has limited impact on mid-term coal prices due to large coal resources. Uncertainty about coal demand driven by climate policy could limit investment in coal extraction and trigger coal price spikes that reduce coal demand. Demand for **natural gas** is initially expected to increase with climate policy due to its low carbon content. Resulting price increases could reduce energy demand and emissions in other regions, but could also drive other regions towards more coal use, thus increasing emissions.

Potential leakage from the fossil fuel channel usually has the biggest leakage impact in macro-economic models (Sijm et al. 2004) and (Barnett et al. 2004). The quantification requires strong assumptions for example about strategic and institutional responses of oil exporting countries to changing oil demand (Burniaux and Martins 2000). The potential impact is hidden, and almost impossible to address with policy instruments. This might explain why it receives less attention in policy discussions. Global cooperation on climate policy is the most suitable policy response and already pursued for several other reasons.

Technology channel: (Grubb et al. 1995) Low carbon and energy efficiency technologies developed and commercialised in countries with ambitious climate policies are likely to diffuse to other countries and contribute to emission reductions in these countries. Governments are discussing how to support this process with technology transfer programs.

Production channel: Carbon intensive production might be relocated to countries with lower carbon prices and associated emissions relocated rather than reduced. The focus of policy discussions – and the chapter - is on this leakage. As the effect is easy to understand, this can be illustrated using the example of specific activities and has implications for clearly identified jobs, and firms. This leakage concerns can also best be addressed with tailored policy instruments.

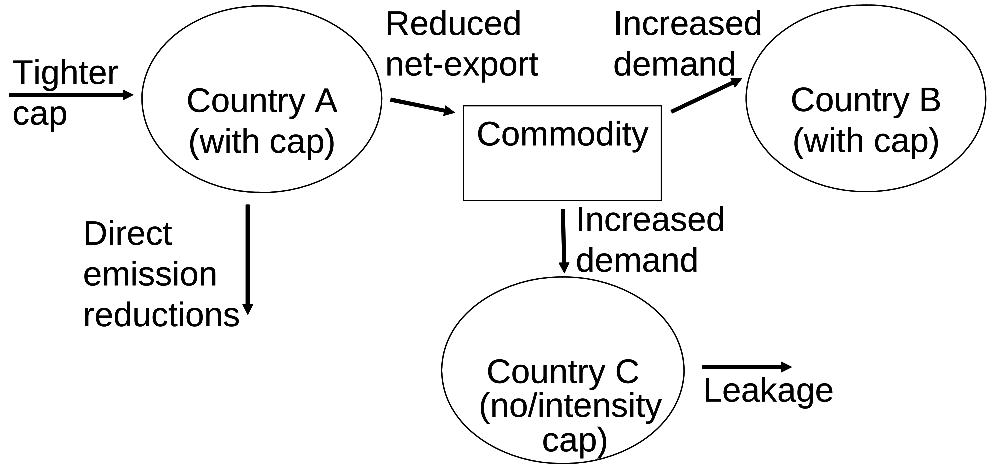

Figure 5.0b: The economics of leakage along the production channel

It is sometimes argued that relocation of production in response to climate policy in one country might not necessarily increase global carbon emissions. Emissions could decline because of improved efficiency of the new facility or a reduction of the overall transport volume for inputs and products.

This however ignores an important aspect of the institutional set-up. Policy makers decide on national and regional emission targets, sometimes unilaterally and sometimes in international negotiations like Kyoto. If policy makers decide on a more ambitious target, then they commit to more ambitious policies, including a tighter cap resulting in higher carbon prices in the trading scheme. Higher carbon prices do not only incentivise carbon efficient investment, operation and consumption, choices, but could also result in an increase of imports or a reduction of export of a carbon intensive commodity.

Figure 5.0b illustrates that reduced net-exports result in increased demand from other countries. This increased demand might be partially satisfied by other countries with stringent emission caps. In this case it would not alter global emissions. The additional demand will however, at least partially, be met through increased production in countries without a binding absolute cap. In these countries the additional production results in additional emissions. As long as some countries remain without a stringent absolute emission cap, relocation of production will thus result in some emission leakage.

As all three effects have the same cause and typically occur in parallel, we will for simplicity group them using the term "leakage concerns". Two additional channels for leakage are not discussed are discussed in text box five. First, carbon leakage can occur where stringent climate policy in some countries reduces fossil fuel demand and thus fossil fuel prices. This could induce demand and thus emissions increases in other countries, thus partially offsetting the emission reductions. Second, low-carbon technologies developed under a stringent climate policy regime can be applied also in other regions and reduce emissions in these regions, thus increasing the effectiveness of unilateral climate policy.

Leakage concerns do not equally apply to all economic activities. They only concern specific carbon-intensive products. For this purpose section 5.1 introduces a carbon cost screen to assess the industry sub-sectors for which carbon pricing significantly increases production costs. Cost differentials are not, however, the only determinants of production and trade; other aspects that impact trade flow and industry's location decisions include the ability of firms to pass through costs, the barriers and drivers for international trade including customer relationships, product differentiation, transportation costs, risks in investing abroad such as exchange rate volatility. These are discussed in section 5.2. Section 5.3 discusses the strategic objectives of corporate decisions that may extend beyond short-term profit maximisation.

Section 5.4 introduces a new dimension. It draws attention to the fact that carbon emissions tend to be focused on the manufacturing of upstream products (e.g. clinker for cement) which are then used as inputs for subsequent production steps (e.g. cement and concrete). A value chain analysis illustrates the role carbon pricing in various stages of the value chain. Building on the findings from the analysis that leakage is only of concern for a very small set of products, the final section 5.5 asks what policies could be used to address leakage concerns for them. It discusses implementation of effective carbon pricing for internationally traded products in a world with differing carbon prices.

5.1 Screening for high carbon costs

From the perspective of the total economy, the potential cost increase from CO_2 pricing corresponds to the volume of emissions. The EU ETS covers about 2 billion tonnes of carbon emissions annually, thus at an allowance price of around €20/tCO_2 the costs incurred if all allowances are sold in auctions is €40 billion per annum. This cost is small relative to the total value added across EU Member States with a GDP of €11 trillion (2005). Carbon pricing would thus only increase costs by 0.4%, a cost change that is swamped by all the other cost differentials between countries. Furthermore, if all the carbon allowances were auctioned by respective governments, the money is returned to the economy via tax reductions or support for low-carbon technologies, thus virtually eliminating a cost impact on the European economy.

In line with this intuition, econometric analysis of the impact of environmental taxes imposed in some European countries over the last two decades shows no negative impact of carbon taxes on industrial activity (Andersen et al. 2007). Similarly, as discussed in a different context in chapter 1, countries with high energy tax levels are economically successful. This again suggests that asymmetric high carbon prices are unlikely to create competitiveness concerns for the overall economy. However, most of the carbon tax and energy tax schemes provided for some exemptions for very carbon intensive products. Therefore the specific effect on these products has to be analysed separately – after all the emissions trading schemes aim to target in particular these carbon intensive products and should therefore not exclude their participation.

As industrial activities are not homogeneous carbon costs have a disproportional impact on specific industrial activities. These are the activities that might be relocated, and where emissions might leak to other parts of the world rather than being reduced in response to a carbon price signal.[75] To identify which activities might be significantly affected, we first analyse the potential cost impact of carbon pricing for relevant industrial activities. Then international trade of the associated products is evaluated because it is a major determinant in the ability to pass through carbon prices to product prices. A simplified metric is used to characterise the trade exposure of manufacturing activities, which allows the screening of different industrial activities.

Figure 5.1 gives an overview of the "potential value at stake" across the main industrial sectors in the UK with potentially significant carbon cost impacts. Although the analysis is based on UK data, it is more widely applicable because the UK has a mix of industrial activities that is similar to the European average.[76]

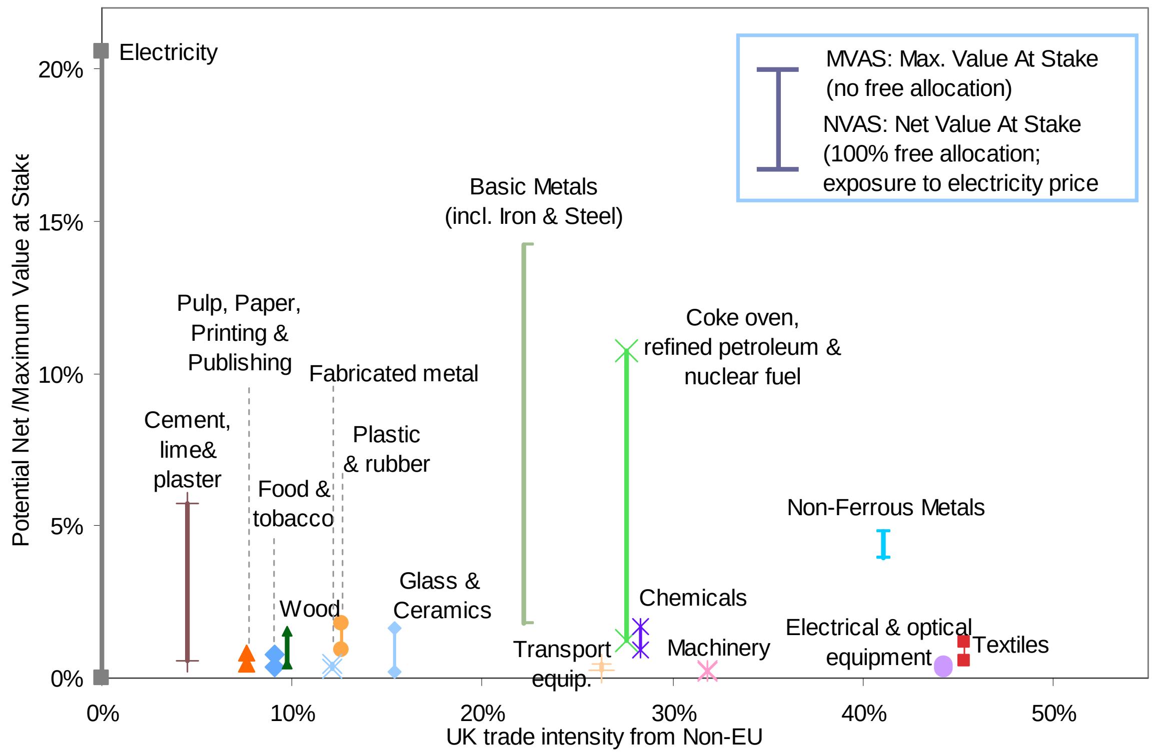

Figure 5.1 Value at Stake for main manufacturing sectors, vs. UK trade intensity from outside the EU, at €20/tCO$_2$.

To allow a comparison across sectors, the cost increase from the carbon pricing is compared to the value added of a sector. The gross value added is the sum of wages, return and depreciation on capital, taxes and profits in a sector. The ratio between cost increase and value added gives the metric used in the remaining part of the section – potential value at stake. This is a measure of how much of the value added created in a sector would be lost if the sector faces the full carbon cost but does not pass it through to the product price.

The lower end of the bars for the different sectors show the "indirect" impact on the costs incurred from the rise in electricity prices. In the UK power system combined cycle gas turbines are usually the marginal generation units with emissions slightly below 0.5 t CO_2 per MWh electricity produced. The electricity producers thus have to submit 0.5 allowances per MWh electricity and will only produce if the revenue from selling electricity exceeds the value of these allowances. Assuming carbon prices of 20 Euro/t CO_2 the power price thus rises by about 10 Euro/MWh.[77]

Carbon pricing also creates costs for direct emissions from energy use by industrial processes. The length of bars in figure 5.1 depicts the range of cost increase if industries bought all their CO_2 allowances. Thus the top end of the bars shows the total potential value at stake for a sector if all allowances have to be bought and if the sector is not able to pass on carbon costs to product prices. If, however, allowances are allocated for free, then sectors will not face cost increases from direct emissions, and the potential value at stake only relates to the electricity price increase depicted by the lower end of the bar.

Producers insulated from trade with regions with low or zero carbon prices are able to pass through the (opportunity) cost increase from carbon to product prices. Electricity producers are the best known example, and so they profit from the scheme with free allowance allocation

For products that are actively traded in global markets it is more difficult to predict the outcome. Firms could increase prices to reflect (opportunity) costs of carbon, which protects profit margins in the case of auctioning and may increase profits in the case of free allowance allocation. This policy may, however, risk a loss of market share from cheaper imports gradually replacing domestic production. Alternatively, firms can maintain prices and lose profit margins if allowances are auctioned. The reality is likely to be somewhere in between depending on the specific characteristics of a sector, which will be discussed in more detail in the next section.

The x-axis in figure 5.1 depicts the level of international trade intensity for the products of a sector, which is also referred to as trade exposure. International trade exposure is obtained by dividing the trade volume by the market size. The total trade volume is calculated as the sum of exports and imports; the total market size equals the sum of domestic demand and imports, or equivalently the sum of domestic production and exports.[78]

Trade-intensity is an imperfect indicator of the ability of sectors to pass on carbon costs to product prices. This is because international trade exposure is a dynamic parameter that depends on, and can change with, the industry structure regionally and internationally. For example, international trade exposure of electricity is zero in the UK because there are no power lines to countries outside the EU ETS, and this is unlikely to change in the near future. International trade exposure is currently also very low for cement, but this could obviously change if there were a sufficiently strong financial incentive. Thus current trade intensity is only an initial static indicator and does not provide a comprehensive assessment of potential leakage for a sector which could be dynamic.

Figure 5.1 depicts a two digit sector representation according to Standard Industry Classification codes. This represents an aggregation of many different activities that are merged under the sector classifications. This can obscure specific activities that might be particularly affected, and may raise concerns for activities that individually have low values at stake. For a more detailed analysis, we therefore move from the two digit to the four digit sector representation.

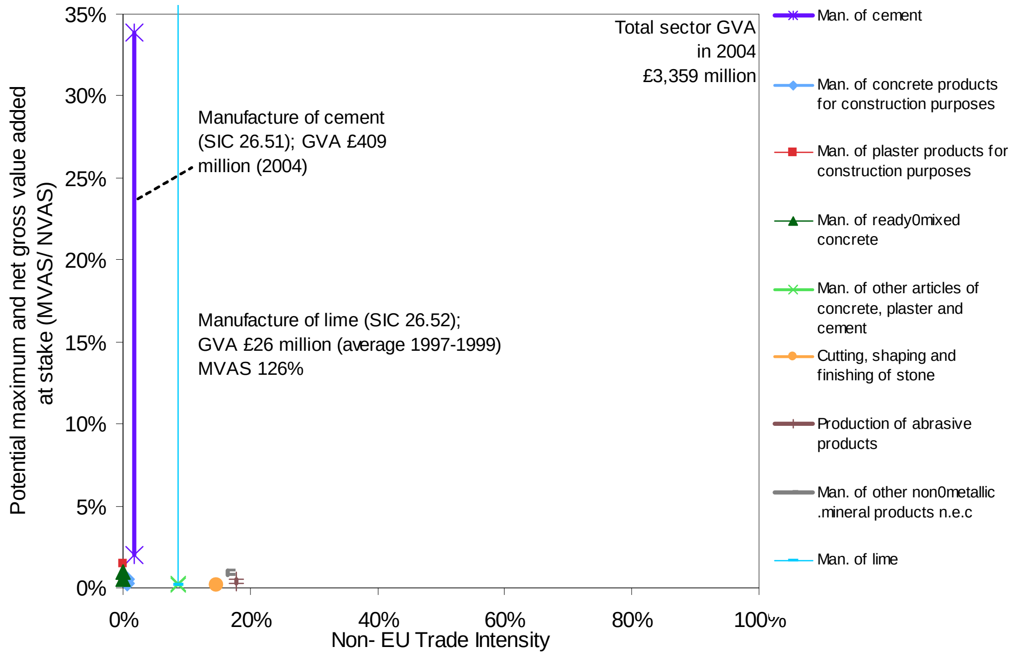

Figure 5.2 Value at stake for construction materials vs. UK trade intensity from outside EU at €20/tCO_2

To illustrate this disaggregation, figure 5.2 gives the different 4 digit sector activities that form the 2 digit sector category construction materials. It shows that only manufactures of cement and lime have high values at stake due to carbon prices. The total value added of these two activities is €0.6 billion, which compares to more complex activities like manufacturing concrete products for the construction process (€1.8 billion) or the overall sector with a value added of €5 billion.

Figure 5.3 summarises the analysis of 164 industrial activities of the economy. It depicts the 24 sectors with the highest value at stake from electricity cost increases and direct carbon emissions. Activities are sorted by their total value at stake, using the same metric on the y-axis as in the previous figures 5.1 and 5.2. The horizontal axis depicts the contribution of the sectors to GDP of the UK.

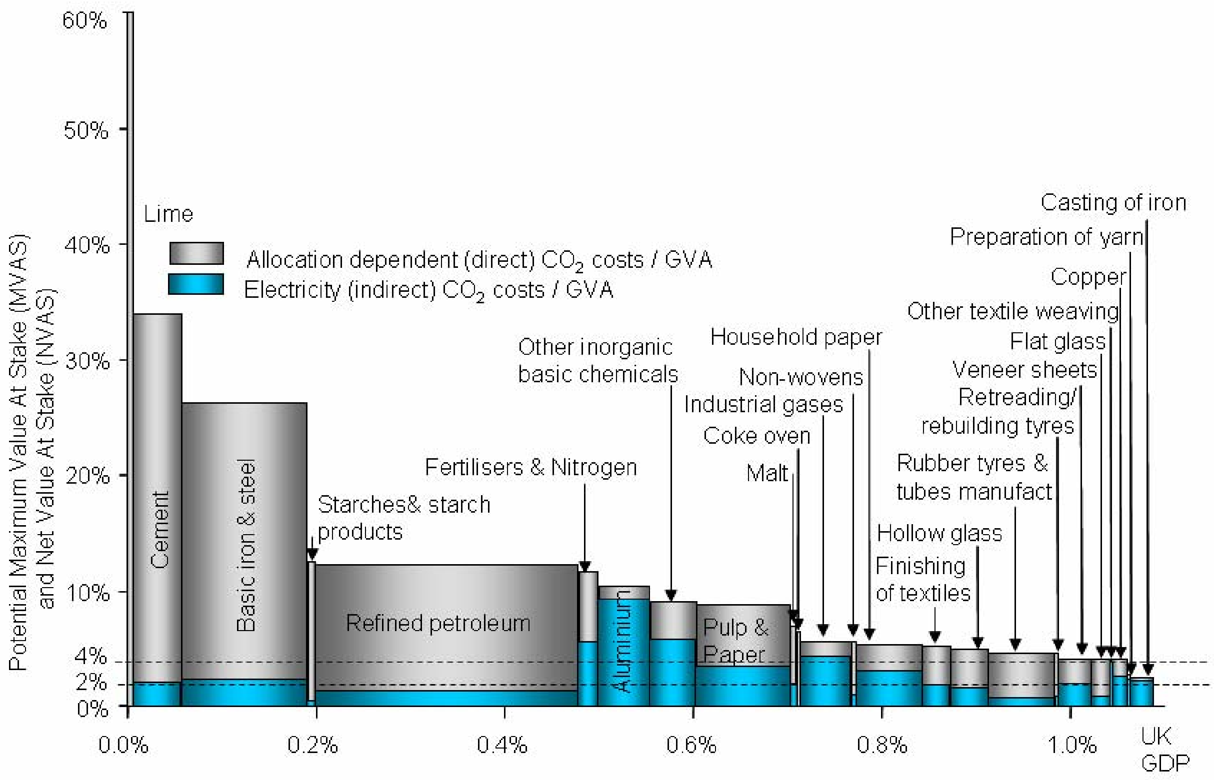

Figure 5.3 Industrial activities with the highest cost increase from carbon pricing, and their contribution to UK GDP, assumed carbon price increase 20 €/tCO_2, electricity price increase 10 €/MWh.

The contribution of each sector to carbon emissions is represented in the graph by the area covered with the rectangle that represents the activity. The area is the product of the value created on the x-axis times the emissions intensity per unit of value created on the y-axis. The 24 sectors with the highest value at stake contribute to about 1% of the UK GDP, and 13% of UK carbon emissions

Lime, cement, basic iron and steel and refineries are the sectors with the highest value at stake from direct carbon emissions. They also contribute most to carbon emissions among the activities that exhibit leakage concerns. Aluminium, fertilizers and some inorganic chemicals including chlorine production, have the highest value at stake from electricity price increases. A high potential value at stake does not, however, necessarily lead to leakage. For example chlorine is a very hazardous substance and consequently can only be transported at high costs between countries. The next section will explore in more detail the potential leakage for these industrial sectors.

The reassuring aspect from the first step of the analysis is that the value at stake in most industrial activities is relatively low, and for the UK leakage is of little concern across 99% of GDP. This result is not unique to the UK - Even in economies with a bigger focus on manufacturing like Germany, only 2% of the GDP are associated with activities that face significant cost increases with carbon prices.

5.2 Do cost differences matter? – dimensions of trade

In this section we first discuss factors beyond production costs that determine trade flows. Then production costs are differentiated between variable and fixed costs, to better understand the implications of high up-front investment costs for the production of commodities.

5.2.1 Components of import costs

It is frequently argue that in a competitive global market the producer with the lowest costs will capture the market and will replace production of all other producers. If government regulation increases the costs of production in one country, this creates a competitive disadvantage and as a result the production will be shifted abroad.

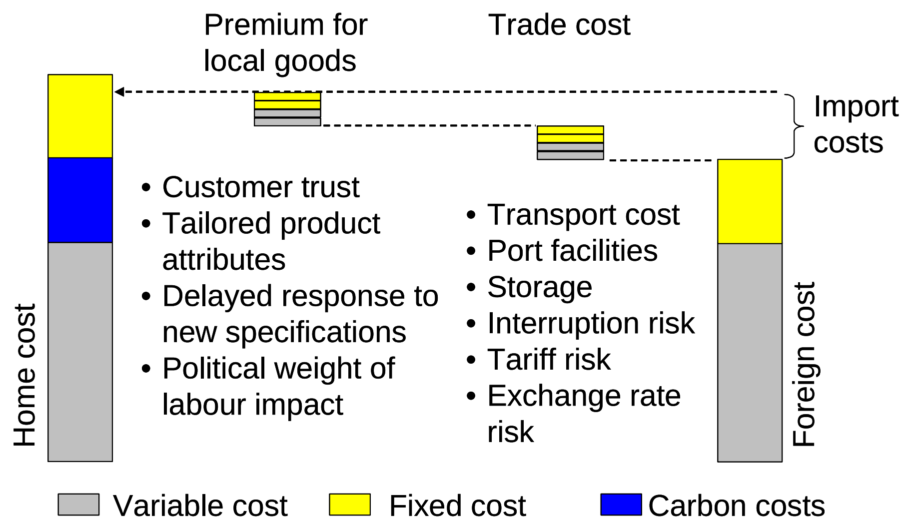

Figure 5.4 Factors determining premia for domestic products and trade related costs for imports.

In contrast to such clear statements - for several commodities production has been maintained and there has even been additional investment observed in regions that exhibit significantly higher fuel costs, wages or taxes. Figure 5.4 depicts factors that allow local producers to charge a premium for their goods and various trade related costs that might explain this phenomenon.

The premium that local products can achieve over imported goods can be explained by several factors. Customers have pre-existing relationships with local producers; proximity helps building and maintaining trust in business relationships, which is particularly important in complex production processes like car manufacturing. The cost of a basic input such as steel is low relative to the risk for the production should delivery or specifications fail when consumer requirements for product specifications are changing over time. Local producers can respond faster than importers, who face delays in communication and longer transport chains. Finally, the level of political influence and attention of firms grows with the number of employees included in the supply chain. Locally sourced inputs can also increase public support during difficult times and have an advantage when seeking investment, R&D support and planning approvals from government.

Also the trade related costs are the sum of many factors. The biggest component is generally the cost of transport, which has risen significantly with the increase in oil prices and the increase in demand for shipping bulk commodities to China, and might rise further if climate policy is applied to shipping and imposes costs for carbon emissions. Trade costs also include the cost of developing tailored port facilities and additional storage to reduce the impacts of interruptions to the supply chain. Export and import tariffs and other trade barriers add to the costs of foreign products.

5.2.2 The interaction between import costs and carbon costs

The combination of the trade related costs and the premium that can be charged on domestic goods will be termed "import costs" in this section. The interaction of import costs with carbon prices is discussed below in three steps. (i) Carbon prices are assumed to be the only difference in global production costs. (ii) Subsequently other cost differences are considered, and (iii) finally the influence of volatile global demand and prices is featured in.

(i) Commodity prices and profit margins have always been unpredictably volatile and therefore capital intensive commodity industries got accustomed to recovering their fixed costs in years of high margins and operating at low margins in other years. This averaged long-term view on fixed costs is the basis of the initial discussion.

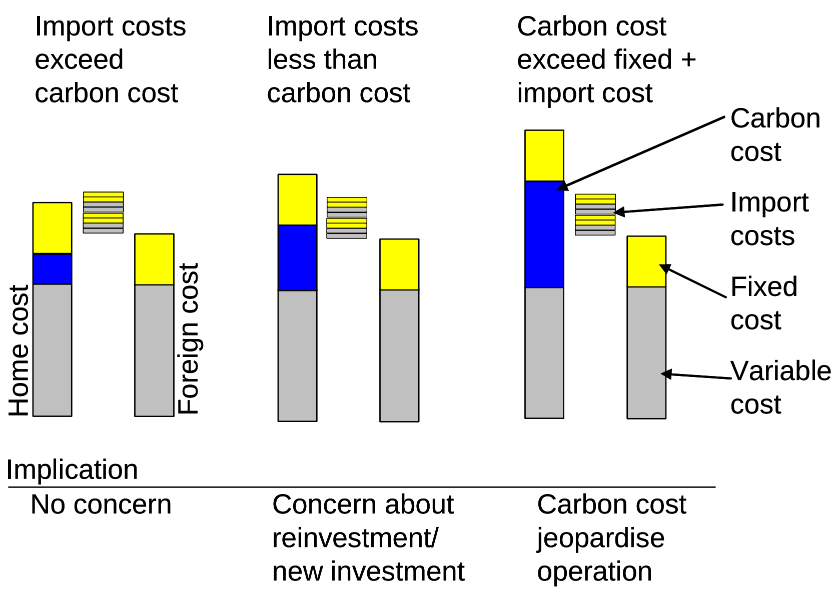

Figure 5.4b. Can local premium and trade costs (import costs) compensate for asymmetric carbon costs?

The left side of figure 5.4b illustrates that if cost structures are identical, and carbon costs faced by home producers are less than import costs, then home producers can pass the full carbon costs onto product prices without any trade impacts.

The central part of the figure illustrates that if carbon costs exceed import costs, home producers can decide to set the domestic price level at the import price level, which is determined by the sum of foreign production costs and import costs. Although it is profitable to continue to produce, the company may not recover all the costs of its initial investment and will not invest in the future. Alternatively, producers can increase their price level above the foreign price level including import costs at the risk of gradually loosing market share.

The right side of figure 5.4b shows that with carbon costs exceeding the sum of import costs and fixed production costs, it is no longer profitable to continue operation. An investor may decide to build new production facilities abroad and replace home production. In this case the new production facilities abroad have lower total costs than the variable costs of the home producer.

(ii) In reality cost structures differ across countries. For example, Brazil has local access to cheap iron ore and coal for steel production and wages and tax levels are lower than in developed countries. This advantage is often compensated, where developed countries offer better infrastructure and a robust regulatory regime, and thus have lower capital costs for investment. In the case of Brazilian steel, the excellent resource situation paired with improving institutional settings offers a significant advantage over production for example in Europe. This is likely to induce a gradual shift of production towards Brazil. Additional carbon costs imposed on European producers could accelerate this shift. Equally, the already intended relocation of a production facility could be blamed on carbon pricing. It will be a challenge for the future debate on leakage to disentangle pre-existing cost differences and industrial trends from the impact of carbon pricing.

(iii) What will happen to a carbon price differential at times of low global demand and margins, when commodity prices can drop almost to variable costs? Eventually global iron or steel production capacity will catch up with demand. Like foreign producers, domestic producers will not be able to recover much of their fixed costs. Domestic producers have to compete with their variable costs including carbon prices against the foreign variable costs and import costs. In this case, if carbon costs exceed import costs, then home production would run at a loss and short-term profit maximisation would require stopping production. At times of global excess supply, the price buffer created by fixed cost recovery is absent, and in this case, short-term responses to carbon price differentials can be more immediate.

In summary, import costs comprising both trade related costs and premia for domestic products, can offer some protection for domestic production from the impact of carbon costs.

For existing facilities fixed sunk investment costs are a further important factor in delaying leakage. The ‘protection’ will, however, be lower where there are pre-existing cost differentials. The imminence of leakage might increase at times when excess production capacities squeeze margins and drive prices towards short-term marginal production costs.

5.3 Corporate strategy – the longer term view

Firms and their managers do not only focus on short-term profit optimisation, but also pursue other objectives that are reflected in longer-term strategies. An important objective for many firms is their market share, which is often an important consideration for the reputation and remuneration of management. Protection of market share can reduce leakage concerns.

Companies benefit from the flexibility to adjust their production volume to evolving demand. They may continue production at a site even where it is not profitable in the short-term in order to retain the option for future production, and hence the flexibility to respond to future demand and customer requests. Furthermore, the costs of closing production facilities can be significant, including compensation for employees, clean-up of sites, and loss of political goodwill and management reputation.

The production of a carbon-intensive commodity is frequently only one of the activities of a firm. There may be links with the production of other less carbon-intensive products and the commodity might be an input for subsequent production processes operated by the firm or part of a range of products offered by a firm. Firms are likely to be reluctant to close their own production facilities and buy from firms with whom they compete in other markets and might prefer to pay a premium to continue production with their own facilities.

The impact of carbon price differentials on corporate decisions is strongly influenced by product attributes and the strategic perspectives of management. The challenge is that multiple story-lines can be used to explain strategic decisions of management in the past and to predict future strategic choices. This makes it difficult to test whether a story line that is presented by a firm in the political process reflects the corporate strategy or aims to influence policies in their favour. This complicates the use of such story-lines as robust evidence for political processes.

Some quantification of how trade flows are influenced by price differentials is in principle possible. Such estimations are calibrated using historic responses of trade flows to price differentials and reflect the various dimensions of import costs (Gallaway et al 2003). It is sometimes argued that the rapid globalisation of producers in the steel, cement and chemical industry reduces some of the import costs and does therefore result in stronger responses of trade flows to price changes. However, at the same time uncertainties are emerging that might counter this effect, e.g. increasing transport costs and other policy responses to climate change. [79]

Figure 5.5 depicts estimates for the impact of carbon price differentials in the case of steel. Historic trade elasticities are used to estimate the impact of the cost differentials on import and export flows (Demailly and Quirion 2007). The first column shows the current production and trade volumes of steel based on the carbon-intensive blast oxygen furnace process. The second column predicts the mid-term impact of a €20/tCO_2 carbon price on European production, which falls because both exports and demand decrease while imports increase. The third column uses higher demand and trade elasticities, so as to illustrate the sensitivity of results to assumptions on input parameters.

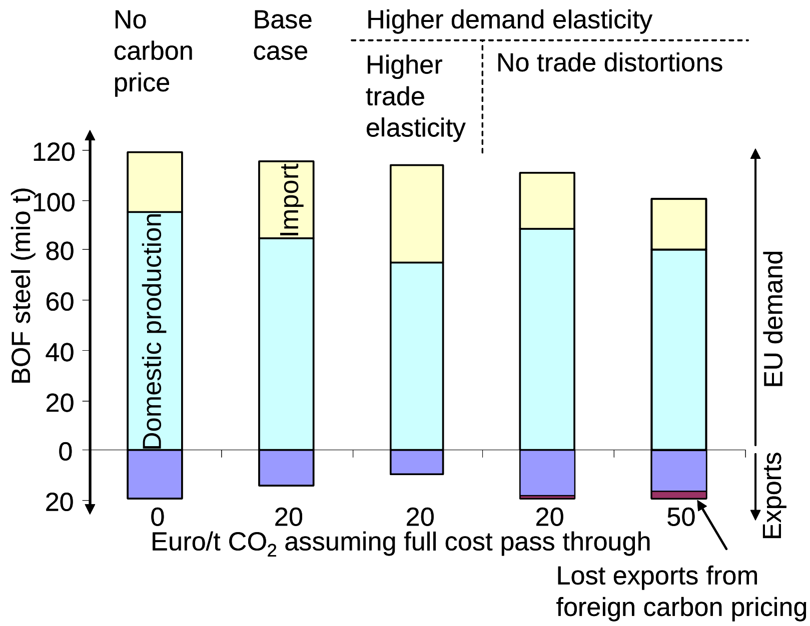

Figure 5.5 Impact of carbon pricing on demand and trade flows for EU.[80]

The final two columns assume that carbon pricing does not distort trade. Distortions are avoided if all countries implement similar carbon prices, at least for a specific sector, or compensate for trade distortions with border adjustment (Chapter 5.5). The higher product prices feed through to European demand and result in a reduction of total demand. As foreign producers are exposed to similar carbon prices, imports do not increase relative to the case of no carbon pricing. Exports still fall relative to the case without global carbon pricing, but to a lesser extend than in the case of unilateral implementation of carbon pricing.

Production activities with the highest values at stake are characterised by large up-front investment costs. They therefore require management to take a long-term strategic view that reflects objectives like market share protection and retaining the real option value of physical production facilities. This suggests that leakage concerns are very much a question of time-frames. Private sector expectations about future carbon price differentials, trade costs and premia for local produced products will determine the level of leakage in the specific sub-sectors with high potential value at stake. But private sector expectations are difficult to quantify and objectively discuss where policy makers have limited, and possibly biased, information about the situation of a company or sector. Discussions about leakage concerns should ideally be based on metrics that can be quantified in an unbiased manner. This would help avoid accusations that environmental leakage concerns are used as a smoke screen to pursue industrial protectionism. In our search for a better understanding of leakage we therefore return to fundamental economic analysis.

5.4 The industry value chain – leakage versus substitution effect

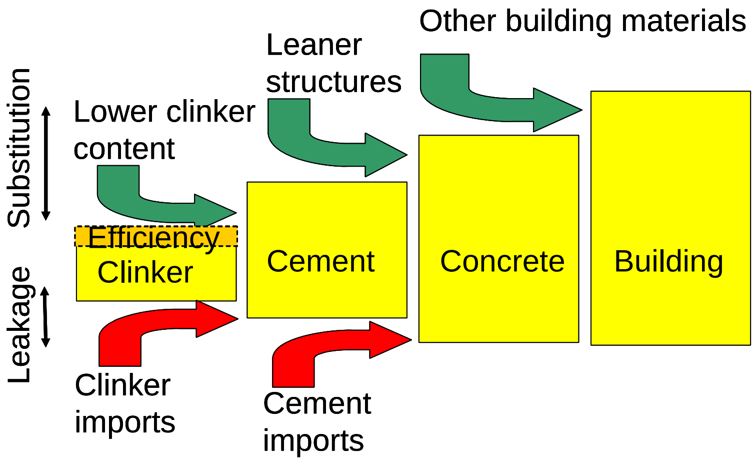

Figure 5.6 Illustration of value chain with potentials for efficiency improvements, substitution and leakage

Industrial products are often linked: outputs of one industrial activity are traded, consumed and are inputs for other production activities. For example, clinker is used to make cement, which in turn is the basis for concrete products that become parts of buildings, which then offer housing and commercial services.

Figure 5.6 illustrates this value chain. As discussed in chapter 1, carbon pricing creates incentives for efficiency improvements in clinker production and drives substitution effects in the subsequent stages of the value chain.

Where leakage is a concern, clinker producers will either refrain from reflecting carbon prices in clinker prices or clinker will be imported. Consequently, users of clinker will not face the full carbon price signal and cement producers will have a lower incentive to make CO_2 performance improvements, such as reducing the clinker content of cement. As a result concrete producers will not be as economical as they could be in using cement and there might not be the necessary substitution of concrete products in the building sector.

We quantify the potential value at stake along the value chain in order to better understand the risk of leakage from foregone substitution effects. In line with the high carbon intensity of the clinker production, the cost increase for this production stage is above 60% relative to the value added (figure 5.7). The subsequent mixing of cement from clinker only requires electricity for milling and, as a result, is not energy or carbon-intensive. If, however, the production of clinker and cement are assessed as a joint production activity, then the cost increase relative to value added (potential value at stake) again exceeds 30%. Moving further down the value chain the carbon intensity of the various types of concrete production is relatively low. Even if production of concrete is jointly assessed with clinker and cement production, the potential value at stake is below 10%. Given the transport costs for concrete parts, it would be unlikely that this would result in any relocation of production.

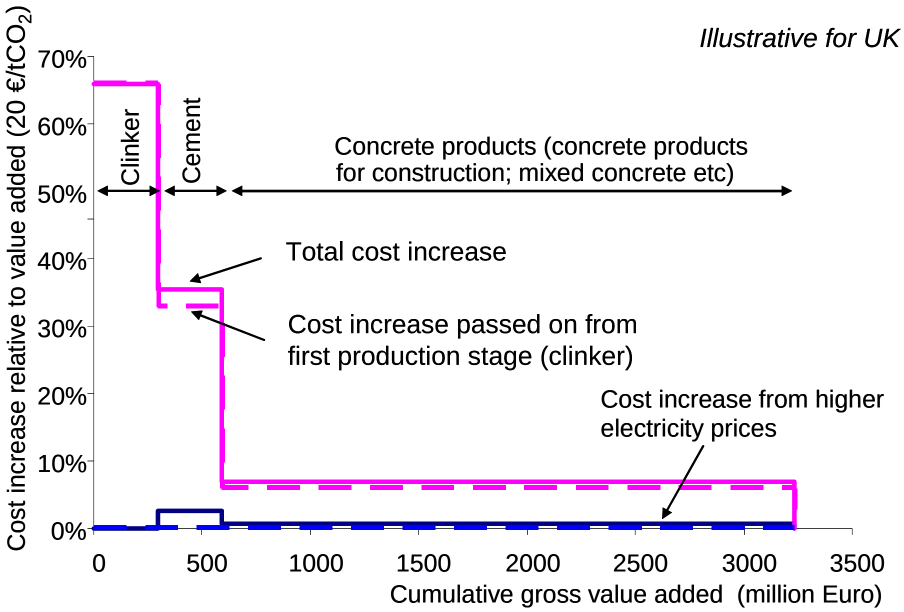

Figure 5.7 Value chain of concrete production

The analysis confirms that with increasing aggregation across industrial activities, the potential value at stake falls. This might hide potentially exposed activities. Even where production activities are currently integrated, new financial incentives created by carbon pricing might result in separation of two activities. Currently most clinker and cement is produced by the same firms at one location. If clinker production faces the full carbon costs, it might well be relocated to areas with lower or no carbon prices.

The analysis also indicates how far down the value chain leakage concerns can persist. The potential value at stake for clinker production indicates strong leakage concerns. If it were possible to prevent such leakage, perhaps by administrative measures that require on site production of clinker (but would be difficult to justify on World Trade Organisation grounds) then cement producers could continue to produce their own clinker despite the higher carbon price. However, the potential value at stake of the joint clinker and cement production would still be rather high, and leakage concerns might persist at this level. Any concerns vanishes once cement is integrated into concrete structures – at this stage the potential value at stake falls below 10% and would be dwarfed by the transport costs for concrete structures.

The situation for steel production is in many ways similar. Figure 5.8 illustrates the consecutive steps involved in steel production. In the basic oxygen furnace iron ore is reduced to semi finished steel. This is subsequently hot rolled and further refined into specific iron and steel products. Most carbon emissions result from the first stage and cost increase relative to value added is highest at this stage. Again, the potential value at stake falls as costs are spread across subsequent production steps.

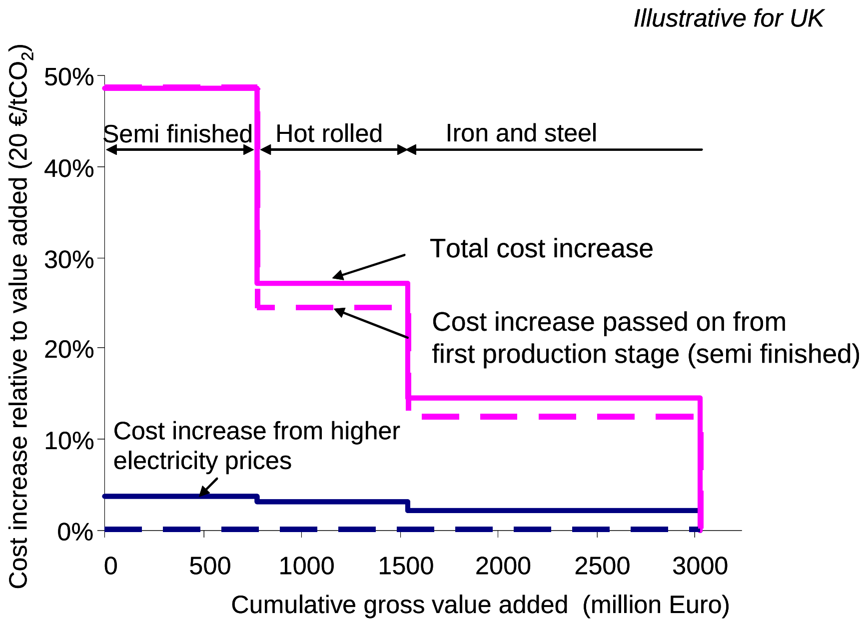

Figure 5.8 Value chain of steel production using BOF process[81]

Even if the cost increase from the carbon-intensive basic oxygen furnace is spread across all the production steps, the cost increase for finished products relative to value added is still well above 10%. Thus the situation differs from the cement value chain. The potential value at stake remains high but the international transport costs are comparatively low. This suggests a need to address leakage concerns for the basic steel component of finished steel. Again this raises the question of whether parts of the value chain can be relocated individually. As the production of semi-finished steel is carbon-intensive, it is the candidate for such relocation. In principle, few countries might be interested in hosting energy intensive and environmental unfriendly basic oxygen furnace. However, one potential candidate would be Brazil, as it has local access to good iron ore and coal resources. Relocation would offer the additional benefit of reducing transport demand for coal and iron ore. On the other hand, integrated steel works combine basic oxygen furnace with hot rolling and can avoid energy consumption in repeated heating cycles. This integration reduces the incentive for re-location. Vice versa, if relocation incentives from high carbon costs are strong, both the plants might in theory be relocated.

The value chain illustrates that carbon intensive production constitutes an even smaller share of economic activity than suggested by the 4 digit standard industry classification. This increases the environmental concern associated with leakage - emissions might migrate outside of the geographical area covered by an emission cap more easily as they are associated with less economic activity and therefore also investment cost. The analysis also confirms the importance of the full carbon price signal. The more complex the production process, the more difficult would it be for governments to administer the efficient use of energy and carbon intensive materials at different stages of the value chain. A full carbon price signal creates incentives for carbon efficient operational and investment decisions along the different stages of the value chain.

5.5 Policy options to address leakage

The preceding discussion illustrated that leakage is only of concern for a few defined sub-sectors and only if significant carbon price differentials are expected to be maintained for many years, e.g. up to 2020. Some of the aspects that will have to be considered in the evaluation of a specific sector are, at least currently, only discussed qualitatively. It might be difficult to find robust quantitative descriptions of management strategies, product differentiation or expected capacity expansion. However, once a concern has been identified for a specific sector, it is desirable to return to a quantitative approach when tailoring the scale of any instrument to address leakage.

Figure 5.9 uses a simplified illustration of the impact of asymmetric carbon pricing, The costs of buying allowances in an auction increases the production costs in one region (blue bar), which could result in relocation of production to the region with lower production costs (right column of each pair).

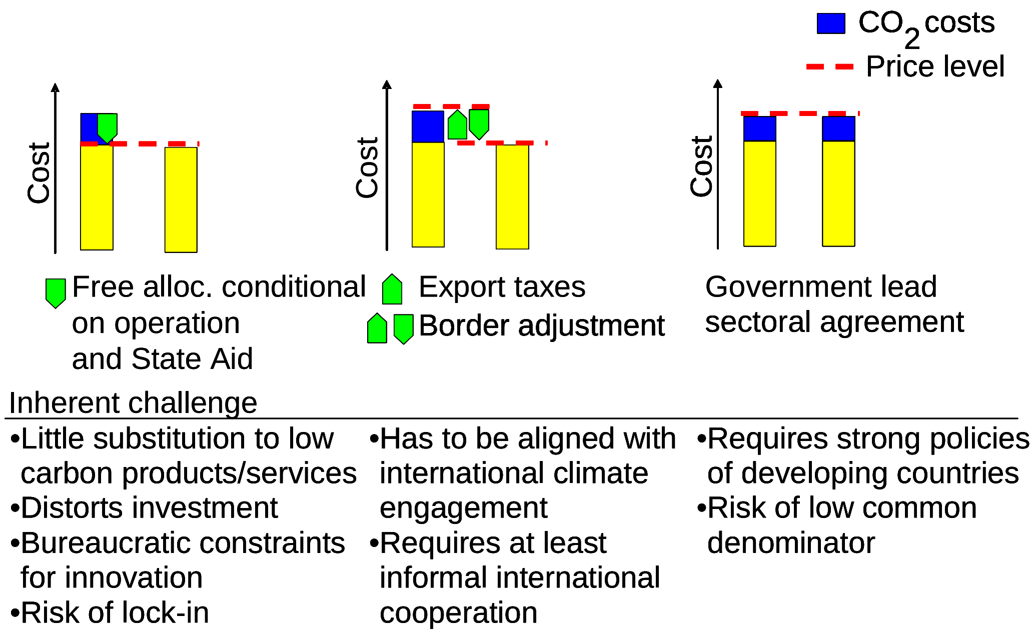

Figure 5.9 Policy options to address leakage concerns

Three basic options are available to prevent such asymmetric cost impacts, and thus to address leakage concern. On the left side of figure 5.9, free allowance allocation or direct financial subsidies (State Aid) compensate for the carbon cost increase. They limit or prevent the cost increase, and all producers compete at the cost level similar to a world without of carbon pricing. In the middle of figure 5.9, export taxes implemented by countries with lower carbon prices, or some form of border adjustment for higher carbon prices, could adjust carbon cost differential if products are traded between countries with different carbon prices, and so recreate a level playing field. The right side of figure 5.9 illustrates how government-led sectoral agreements could create the same carbon price for all competing firms. This is similar to a global carbon price, but it might be only focused on specific sectors. All three options ensure all firms face comparable carbon costs, and thus create a level playing field with regard to the carbon price.

Which instrument is most suitable to address leakage depends on the specific sector. To discuss the possible options, the characterisation of leakage concerns introduced in figure 5.4b is refined. The concerns about reinvestment and new investment are separately assessed and the case where operation is jeopardised is differentiated so as to separately assess concern about reduced production and about closure of plants.

New investment: for products with increasing production volume in a scenario with asymmetric climate policies, the plant investment could be shifted to regions with lower carbon prices in a scenario of asymmetric carbon prices. This new investment decision is probably most sensitive to carbon price differentials. However, with stringent climate policy few carbon intensive commodities will be required at larger volume and little new investment is required for their production in developed countries.

Reinvestment: even with constant or declining production volumes, plants require ongoing investment, maintenance and upgrading to match evolving product and environmental requirements. If these investments are not pursued, then it is likely that production of a plant will decline perhaps to eventual closure. This is of concern where reinvestment requirements are high relative to the cost of new (green-field) investments and where there are limited technical links with related manufacturing activities.

Reduced production with potential closure: if carbon costs of production are large relative to annual fixed costs of an installation, then firms gradually reduce production volumes where they face increasing import volumes.

Closure of plant: if carbon costs of production and fixed annual costs are large, then producers typically face the decision of full production or closure of an installation rather than gradual adjustment of output.

All four cases could result in some movement of carbon intensive production from installations covered by an emission cap to other regions. Thus emissions reductions induced by the cap and trade scheme would not be genuine reductions, but would be offset by leakage of emissions. We will subsequently refer to these four categories as leakage channels:

Table 5.1 lists three carbon intensive production processes that might exhibit such leakage concerns. They serve as an example to show how production process could be exposed to different leakage channels and to assess which policy instruments might be most suitable to address these concerns.

	Investment	Re-investment	Reduction/ closure	Direct closure
Steel production (BOF)		**X**		**X**
Clinker (Cement)			**X**	
Steam reformers (Chemicals)	**X**			

Table 5.1: Potential leakage channels illustrated at the example of some potentially effected commodities

5.5.1 State Aid or free allowance allocation to subsidise carbon intensive production

Governments can shield carbon intensive production from the full carbon price. Free allowance allocation can be used to subsidise production or investment in sectors with direct carbon emissions.[82] Direct public subsidies can also support investments and re-investments in sectors that are facing either high costs from carbon emissions or significant cost increases from electricity price increases. In Europe such subsidies by Member States are called State Aid, and are regulated European wide so as to limit distortions of competition between Member States. The typical approval process by the Commission for State Aid granted by Member States offers the opportunity for a less political decision process that could allow for better targeting subsidies to installations with demonstrable leakage concern.

For **steel production**, the fixed operating costs are high. Therefore producers have to decide whether or not to operate an installation. They may not have the choice of gradual reduced output. Thus free allowance allocation can be linked to total production capacity with some benchmark value. Allocation has to be conditional on continued operation to create the necessary incentives, but does not require a link to the precise production volume. The implementation of similar provisions in the first two national allocation plans suggests that firms can choose the timing of closure of installations so as to retain continued allocation for almost two years after closure. This reduces the incentive for continued operation of plants.

Alternatively, State Aid could be used to support reinvestment decisions of firms. Further analysis is required to assess whether the re-investment volume which limits the amount of State Aid that can be allocated, is sufficiently large to have a material impact on addressing leakage, and to what extent such re-investment can be separated from operational costs that would not be covered by State Aid.

The situation differs for **clinker** (the carbon intensive input material for cement). For clinker the relative costs of CO_2 are high. Therefore allocation based on a capacity benchmark could result in reduced production volumes. Free allocation proportional to some recent production volume of clinker would be required to address leakage concerns in this sector with domestic subsidies. This approach will, however, dampen the product price increase of clinker and throughout the cement value chain. Hence it dampens the incentives to reduce the clinker content of cement, the amount of cement in concrete, and the amount of concrete in buildings. Thus free allowance allocation proportional to recent production volumes forgoes much of the desired incentive for substitution towards lower carbon materials for constriction.

The allocation of allowances could be made proportional to the output of cement production rather than output of clinker production in order to retain the incentive to reduce the amount of clinker in cement. This would not address emissions leakage as cement producers can import the carbon-intensive intermediate product clinker. [83] Constraints to prevent this might be difficult to justify under WTO rules. [84]

The allocation of allowances based on benchmarks requires a precise definition of the production process and qualifying products. If, for example, the specifications of clinker are not clearly defined, it could create incentives for producers to add clay to clinker production. This would increase the volume of ‘clinker’ and thus the amount of free allowances that are allocated proportional to the volume of clinker produced. If instead, the processes and product is very narrowly defined, then the flexibility of operation, investment and exploration of substitutes is reduced, thus increasing overall costs of emissions reductions.

Finally, **steam reformers** are part of large chemical installations. Existing steam reformers are therefore likely to continue their operation as part of the overall facility. State Aid could support new investment and large-scale reinvestment, should a detailed analysis demonstrate that they are at risk of relocation in a world of asymmetric carbon prices.

Table 5.2 summarises which approach seems most suitable for different sectors.

	Benchmark on capacity	Benchmark on production	State aid
Steel production (BOF)	**X**		**?**
Clinker (for cement)		**X**	
Steam reformers (Chemicals)	**?**		**X**

Table 5.2 Instruments to address leakage for production of different commodities

All three policies have unintended negative side effects. They create **administrative processes** that link allocation of subsidies to carbon emissions of a plant. This will undoubtedly create an early action problem – where agents expect their actions today can allow them to capture future benefits from public subsidy rather than from emissions reductions. This will distract and possibly distort investment and operational choices.[85]

Subsidies to carbon intensive production also reduce product prices and thus the economic incentive to shift towards lower carbon production technologies and/or product substitution. To compensate for this, the carbon price increases and additional mitigation efforts are pursued in other sectors. This deviation from the first best distribution of mitigation efforts increases the costs of climate policy.

From an international perspective, the continued use of subsidies, and particularly the use of free allowance allocation, might lead to a lock-in to inefficient policies. Countries decide sequentially on their allocation plans for allowances. Once all countries have implemented such provisions, extensive coordination is required to phase out subsidies. Perhaps early international cooperation can ensure sun-set clauses are in place to facilitate the move to an efficient carbon pricing scheme in the long-run.

Subsidies can address leakage – but at a high cost. They limit incentives for emissions reductions and innovation in the sector where they are applied. Therefore the cost of delivering emissions reductions has to be bourn by other sectors of the economy. It reduces the incentive for industry to develop low cost options for emissions reductions that can be replicated in developed countries.

The ongoing debates and emerging concepts for carbon trading at state and federal level in the USA, Australia and recently Japan illustrate that allocation and competitiveness are an intrinsic challenge for the implementation of effective carbon pricing schemes. The first response of industry representatives is to argue for free allowance allocation to address leakage concerns. From the perspective of firm owners, any free allowance allocation guarantees profits. From an environmental perspective free allowance allocation has to be conditioned on operational and investment choices of firms to address leakage concerns.

Different responses can be observed that are pursued to address leakage concerns. The Regional Green House Gas Initiative will implement a cap and trade scheme for the power sector in New England. Most of the participating states that have decided on the allocation methodology envisage 100% auctioning of allowances. Leakage and competitiveness distortions, mainly relative to neighbouring states, will be monitored. At this stage no explicit measures are envisaged. In the discussions on carbon pricing by the Western Climate Initiative, leakage relative to neighbouring states is again an important topic. Both free allowance allocation and border adjustment are discussed as measures to address concerns. The various proposals for a US-wide emissions trading scheme currently discussed in the US Senate envisage free allowance allocation and border provisions to address leakage concerns. Australian and New Zealand industries are voicing concern about competitiveness and leakage in the discussion of the design of these schemes. Free allowance allocation to exposed sectors is again proposed. The Draft Directive for the design of the EU ETS in the period 2013-2020 suggests that the European Commission should identify by 2011 sectors that are subject to leakage concerns. For these sectors sectoral agreements, the use of export taxes, and free allowance allocation are suggested as potential options to address leakage concerns.

This evolution raises one significant concern. Different countries might implement domestic measures to address leakage, in particular free allowance allocation and State Aid. Any big country pursuing such a strategy will set a precedence that might be followed by other countries. Thus national and regional emission trading schemes might be using inefficient means to address, in some instances even unwarranted, leakage concerns. It will be difficult for subsequent countries to implement more efficient schemes, or for any country to individually shift to a more efficient design. This illustrates the importance that has to be attributed to the decision on instruments to address leakage, so as to avoid lock-in to an inefficient design choice.

5.5.2 Sectoral agreements to address leakage

Activities on sectoral agreements can be observed in the steel, cement, aluminium and some initiatives in the power sector, and typically involve voluntary agreements on sharing of best practice and collection of information for this purpose.[86] Such sectoral cooperation can play an important part in accelerating the response of industry to climate change policies.[87]

Sectoral agreements to deliver full carbon price

One could envisage that governments want to focus their negotiations on a specific sector, for example to demonstrate the viability of carbon pricing. What could be the shape of a successful sectoral agreement for a specific sector that allows for a full carbon price and avoids leakage concerns?

Such an agreement would require a commitment of all participants to impose the full carbon price, i.e. prohibiting subsidises for domestic industry for example using State Aid or free allowance allocation. This commitment has to be credible not only for the high commodity prices of current times, but has to endure periods of potential excess capacity when some producers might face the risk of bankruptcy.

This raises the question: how would the carbon price be defined under such an agreement? A trading scheme could be implemented for all installations covered by the sector in participating countries. It would imply that the sector would no longer be covered by the national trading scheme – an option that has not received any support at European and Member State level.

The approach would also not allow for smoothing of uncertainty about production volumes and technology innovation that is possible with trading schemes across sectors.[88] Therefore the agreement could focus on explicit carbon prices and set a fixed carbon price for all installations in the sector. It is difficult to see how an international discussion among governments and their national champions could set such price at an appropriate level.

Alternatively, an international agreement could determine the minimum carbon price that would have to be set for installations in the sector, thus allowing individual countries to retain these sectors in their larger domestic trading scheme as long as the national scheme exceeds this price level. Implementation of either of these approaches on a global scale would likely be an ambitious enterprise.

Sectoral agreements have to be government-led if they aim to address leakage. Even if big companies cover most of the emissions in a sector, the experience of the Indian steel sector illustrated the ability of smaller firms to grow rapidly – thus undermining any agreement among big companies. The national government is required for the implementation of a consistent policy that covers all installations.

Sometimes it is suggested by industry that trading schemes could be developed that reward installations in developing countries for lowering emissions and create incentives for voluntary participation. However, this would imply that old, inefficient plants in developed countries would fund investment in new and efficient plants in developing countries. It is, however, unlikely that plants in developed countries would agree to subsidise their competitors.

Sectoral agreements based on benchmarks are not necessary to address leakage. Most proposals for government-led sectoral agreements envisage determining a benchmark emissions rate. Companies with emissions per unit of product that exceed this benchmark have to buy allowances to cover the additional emissions. If an installation produces fewer carbon emissions per unit of production than the benchmark, then it receives allowances for this difference and can sell the allowances. This creates the desired incentives for efficiency improvements in production. However, like free allowance allocation based on benchmarks, the approach creates administrative constraints that restrict flexibility for operation and investment. Also, the approach reduces the production costs of efficient installations and only creates carbon costs for the inefficiency of installations, not for the full carbon externality. As a result, it will not drive consumers to explore substitutes or use carbon intensive commodities more efficiently.

If the policy does not result in a price increase for the carbon intensive commodity, then it does not create any leakage concern. But if there is no leakage concern, then no international approach is necessary to pursue the policy. Therefore again the sectoral approach can equally be pursued with the objective of cooperation to enhance emissions reductions, and be relieved from the poisoned pill to negotiate among industry a solution that avoids leakage.

In summary we can say that concerns about leakage only arise in carbon pricing schemes where producers pay the full price of carbon. Sectoral agreements are only required to address leakage if there is the ambition to impose the full carbon price as part of the agreement.

However, there is little indication that this is the ambition of any of the schemes. Therefore it might be preferable to remove the objective of avoiding leakage from the discussions of sectoral approaches. This will increase their effectiveness in engaging a wider set of countries in pursuing climate policy.

5.5.3 Border adjustments

The **economics of border adjustment** are simple. If leakage occurs because producers face higher carbon prices, then leakage can be avoided when imports and exports are adjusted for the carbon price difference. Thus the full carbon price signal remains intact and creates incentives for innovation in new production processes, products and services and supports the substitution towards lower carbon options.

The idea is already widely applied in schemes of value added taxes: for a car sold in Germany the sales price includes the value added tax that was accrued over the various production steps. A private resident of Switzerland who buys a car in Germany initially bears the German value added tax, but gets a full refund when exporting it from Germany. The Swiss customs office will levy value added tax at the Swiss level when the car is imported. Thus all cars competing for consumers in Germany include the German value added tax in their sales price. Where they compete for Swiss consumers, the sales price includes value added tax at the Swiss level. Thus competition is not distorted despite the differing levels of value added tax across countries.

The **WTO compatibility** of border adjustment can be ensured through careful implementation.[89] For this, the scheme may not differentiate between like products by foreign and domestic producers without due justification. This requirement is met when charges levied at the border for imports or reimbursed for exports do not exceed the carbon costs of producing with best available technology. Also, border adjustment can only be applied to the extent that installations pay for their allowances. Border adjustment is not possible to the extent installations receive free allowances or State Aid.

The **politics of border adjustment** are more challenging. Developing countries have experienced a long history of border provisions with adverse impact on their economic development. This situation was not simplified by various proposals to use border measures as a stick to enforce participation in climate policy.[90] Therefore, the clear anchoring in the general rules of the WTO is important to prevent policies that are initially targeted to address leakage concerns for a specific commodity to extend in scale or scope. This can involve international cooperation that clearly limits the scale and scope of border adjustment on carbon prices.

Indeed, rather than creating barriers between countries, border adjustment for carbon price differentials could support international cooperation on climate policy e.g. by using net revenues to support climate policies in developing countries. More importantly, border adjustments allow countries to implement carbon pricing schemes with higher carbon prices so as to increase their decarbonisation effort which is beneficial for all countries.

The political sensitivities associated with border adjustments require that they are discussed and implemented in close international cooperation. This creates trust and shared understanding among all parties about the objectives and limitations of border adjustment. Border adjustments are not required before 2012. This gives sufficient time for their international discussion. The EU can engage in these discussions open mindedly, because it retains the alternative options of state aid or using free allowance allocation for exposed sectors.

For the **implementation of border adjustments,** governments can choose whether the adjustment is done in allowances or in money. In the first case, importers have to acquire allowances in the market or in auctions to cover the emissions associated with the production of their goods at the adjustment level while exporters are compensated with allowances. Alternatively the adjustment rate can be multiplied with the market price for carbon allowances to determine the import levy or export refund.

It also has to be decided how far down the supply chain a border adjustment is applied. For example in cement production the carbon-intensive commodity is clinker. Adjustments are applied to clinker at the level of carbon intensity of producing clinker with the best available technology. As a result clinker costs and prices increase. This increases the costs of cement production and might result in some relocation unless border adjustment is also applied to the clinker content of cement. It is, however, not necessary to apply adjustments to products further down the supply chain. The cost increase for concrete products due to higher clinker and cement prices are low relative to transport and other trade costs.

The adjustment would be limited to a small number of specific, carbon intensive commodities (i.e. clinker and cement, not concrete; the steel content of refined steel, not of cars). This adjustment process could probably be pursued based on existing customs law and its product categories, and would therefore not require significant additional administrative procedures or costs for governments or private sector.

Border adjustment is politically contentious, but might well be implemented effectively – if pursued in an international framework that engages all countries. This would clearly limit the scale and scope of adjustment to ensure it addresses leakage. Thus ambitious countries could pursue stringent emissions reductions.

5.6 Conclusion

The preceding chapters argued that if the level of domestic support exceeds the internationally agreed commitment level, countries could aim to pursue more ambitious climate policies. To have an effect on investment decisions these domestic policies require commitment to mid-term targets that will probably involve higher carbon prices than in other countries or regions.

This chapter examines the question of whether such differences in carbon prices would cause leakage by causing firms to relocate production into countries with lower carbon prices. In these circumstances carbon pricing would shift rather than reduce emissions. As leakage is a concern for internationally traded commodities, this would imply that prices of the affected commodities would not increase to reflect carbon prices. Thus leakage would also undermine the substitution effect. With relocation of industrial production countries with high carbon prices may lose some jobs and tax revenue, which would undermine political support for the carbon pricing scheme and the interest of other countries in implementing ambitious carbon pricing schemes.

Sector specific analysis shows that leakage is not an economy wide problem. It is only of concern for particular sub-sectors. For example, in the UK, carbon pricing results in non-trivial cost increases for only 24 sub-sectors, and these sectors represent only 1.1% of the GDP and about 2% in Germany.. Whether leakage concerns are material for these sectors depends on sector specific characteristics; for example: trade intensity, the origin of input factors, the ability of producers to address tailored needs of local consumers, the ratio between fixed and variable costs as much as the expected capacity expansion. If carbon price differentials are expected to persist over long time periods, then they might contribute to investment decisions for relocation in these sectors.

The approach that is currently envisaged for cap and trade schemes is to use free allowance allocation to compensate the sectors with strong leakage concerns about carbon cost increases. To effectively address leakage, such allocation has to be conditional on continued operation, perhaps even conditional on specific production volumes and product types. This creates bureaucratic constraints and perverse incentives, which limit the effectiveness of cap and trade to increase carbon-efficiency, foster innovation, and drive substitution towards lower carbon commodities. Although from an environmental and economic perspective free allowance allocation is the least desirable approach to address leakage concerns, it is an established procedure, and therefore relatively easy to implement. It protects profits and also undermines the substitution effect that could reduce future market volumes for high-carbon products, and thus receives significant lobby support from incumbents in the affected sectors.

In the European discussion the use of State Aid – explicit subsidy for investment and reinvestment choices – receives increasing attention as a means to address leakage concerns. As State Aid rules are designed, and enforced, at the European level, but aid is granted usually at national level, this approach might offer an opportunity to move towards a less politicised and more technical decision process on the sectors affected and the level of support required. It is too early to judge whether the approach will succeed, and whether it could be replicated in other institutional settings.

Government-led sectoral agreements have been proposed as alternative approaches to address leakage concerns while retaining environmental effectiveness. They could focus on delivering a similar carbon price in all relevant countries for a specific sectors. This would create a level playing field and avoid leakage. However, they would probably be complex to negotiate and implement. Perhaps it is preferable to remove sectoral approaches from the agenda in order to properly address leakage. Then sectoral approaches can be used to target opportunities that emerge from combining public and private sector expertise and initiative, for example by sharing best practice. This will accelerate international cooperation on climate policy.

Different approaches to border adjustment could compensate imports or exports of individual commodities for the production cost differential directly associated with different carbon prices levels. Border adjustments are economically efficient, and can be designed so as to be compatible with WTO rules. However, if pursued unilaterally, they risks repercussions for international cooperation on climate policy. The political sensitivities associated with trade related measures require that border adjustments are only pursued in an international context that ensures trust and shared understanding of the purpose of the measure and limits scale and scope so to specific commodities where leakage concerns are clearly demonstrated.

As these debates evolve in parallel in many countries, one big concern is that all schemes might 'lock-in' to a second best solution. As some countries start to use free allowance allocation or direct subsidies, others will follow. It might subsequently be difficult to find a way to alter these designs. Given the creation of vested interests, future improvements would be particularly difficult where time frames for allocation decisions differ between countries. Thus initial measures to address leakage concerns might seriously undermine the effectiveness of cap and trade schemes. Sunset provisions might improve the situation by conditioning free allocation to ongoing leakage concerns. The common challenge all countries face suggests benefits from cooperation on analysis and policy design.

6 Summing up – Tackling Carbon

Reducing the risk associated with climate change demands a large decrease in carbon emissions. Governments can choose from a set of policy instruments to deliver these emissions reductions. Carbon pricing will be an essential part of any solution.

Many economic activities create significant carbon emissions, which makes it difficult for governments to micro-manage individual carbon policies across the wide variety of industrial, commercial, housing, and transport activities. Carbon pricing allows governments to create incentives for firms and consumers to make carbon-efficient choices across a diverse set of activities. Firms and consumers then have the flexibility to find the response which is most suitable for their specific circumstances. While initial evidence from the impact of the European Union Emissions Trading scheme on carbon-efficiency is encouraging, empirical evidence from energy usage in OECD countries is robust. Energy prices differ across countries due to the varying levels of natural resources as well as varying levels of tax imposed on energy consumption. Countries where energy prices are high require less energy per unit of GDP than countries with low energy prices. This suggests that **carbon pricing is an essential policy instrument to deliver emissions reductions**.

Chapter 1 discussed how a price on carbon increases the costs of operating carbon-intensive technologies, and thus makes it more profitable to invest in and operate lower carbon technologies and to pursue research and development on innovative low-carbon technologies. A carbon price also increases the cost of carbon-intensive commodities, products, and services and creates incentives for firms and consumers to choose lower carbon substitutes.

Carbon pricing is politically challenging. To alter choices by firms and consumers the prices for carbon-intensive products and services have to rise. Most of this price increase reflects additional costs from carbon allowances or carbon taxes. The use of this revenue will determine who wins and who loses from the introduction of carbon pricing. It will therefore be a politically sensitive question. If major consumer and industry groups consider a scheme to be fair and equitable, then it will be robust and able to deliver effective carbon prices.

Carbon pricing alone, however, is by no means sufficient for effective climate policy. The economic literature has identified a large set of barriers for the implementation of apparently viable energy efficiency and low carbon opportunities. Changes to regulatory and institutional frameworks are needed to remove these barriers. Targeted policies are also required to provide the necessary information and raise consumer awareness and management attention to the carbon implications of decisions. Without these complementing measures it is likely that carbon pricing would not be as effective as it could be. Conversely it would be difficult to implement far-reaching regulation on carbon-efficiency without a carbon price signal. Consumers and firms might for example try to circumvent regulations and avoid carbon-efficiency investments if they do not benefit from savings on carbon costs. Thus carbon pricing and regulation are two complementary pillars of climate policy.

Another significant aspect of climate policy is the development of low-carbon technologies. Since there are often various market failures surrounding technology innovation, governments are generally expected to support research, development, and, in some instances, diffusion of low-carbon technologies. Again synergies between technology policy and carbon pricing exist. Irrespective of government support, the private sector only devotes resources to the development of low-carbon technologies if it anticipates profitable future markets. If a low-carbon technology is expected to compete with conventional technologies, then the future market will be more profitable with future carbon pricing.

Emissions trading can effectively deliver a carbon price. Chapter 2 discussed how the first cap and trade programs were implemented in the early 1990s in the USA for SO_2 and NO_X. Building on this experience, the European Union Emissions Trading Scheme was implemented in 2005. The pilot phase, lasting until 2007, delivered a functioning market, focused management attention on the role of carbon, and influenced operation decisions particularly in the power sector. At the same time the pilot phase illustrated difficulties, in particular the distortions from repeated free allowance allocation. In subsequent allocation decisions the methodology was improved. Current discussions about the EU ETS demonstrate the political will to move towards auctioning allowances post-2012 to remove the remaining distortions. It is encouraging to observe how emissions trading designs emerging in Australia, New Zealand and various North American states build on these experiences, and for example forward auctions scheduled under the REGGI scheme for September 2008 go beyond the level of auctions implemented in Europe.

Cap and trade policies can provide an effective framework for investments in low-carbon projects and energy efficiency measures, which will deliver the majority of future emissions reductions. To ensure this investment is forthcoming despite uncertainties about technologies, fuel prices and the limited ability of governments to commit to future policies, the specific needs of investors have to be understood and addressed. To this end, chapter 3 described the variations in investment perspectives and decision making processes across sectors.

For example oil and technology companies have long-term perspectives on the market share of fuels, technologies and their products. Policy decisions can influence their expectations and thus investment decisions. However, this requires a credible longer term policy framework. An emissions target in 2020 is credible if the carbon price for 2020 adjusts so as to ensure that the target will be met. The carbon price has to rise, if energy efficiency measures or carbon capture and sequestration turn out to be more expensive, to secure an appropriate market share for low-carbon technologies. This will ensure their remuneration and allow investors to pursue low-carbon strategies.

In contrast to a long-term perspective, investors in individual projects typically focus on the return over the initial five to ten years. Their investment decisions are typically based on existing legislation and regulation, and often take current carbon prices and their volatility as representative of future prices. For such investors, stable and predictable carbon prices reduce uncertainties and risk, thereby facilitating access to cheaper capital.

The discrepancies between these two perspectives are part of the bigger challenge of aligning short and long term perspectives. Short-term emissions reduction targets are typically based on assessments of available technologies and might lend themselves to carbon taxes. Long-term targets reflect the need to avoid extreme climate impacts and the expectations about technology improvements and innovation, and are likely to be more suitable for emissions trading.

The implementation of emissions trading offers flexibilities to bridge this gap. Investors with shorter-term perspectives can be protected from the risk of extremely low-carbon prices, for example, with a reserve price in auctions or government issued put options. The credibility of future targets increases with a consistent and widely shared vision of the trajectory towards decarbonisation and implementation of the necessary policy instruments. A cap and trade scheme can play an important part in this policy mix, as it ensures the carbon price adjusts to technology cost and fuel prices so as to deliver the target.

The importance of credible commitment to mid-term, e.g. 2020, targets for low-carbon investment raises a set of questions in chapter four about which sectors and regions should be covered by an emission trading scheme and about the timing and coordination of commitments by countries and regions. On the question of coverage, the first instinct of economists and traders is to argue for one common scheme with trade in emissions allowances across sectors and countries. Trade across sectors and countries allows market participants to identify the mitigation options that can be pursued at lowest costs, and can thus reduce overall economic costs of emissions reductions. This is, however, not the only criterion to be considered.

In different sectors carbon prices will trigger varied levels of demand response and innovation while the impact on equity for consumers also varies. In addition, pre-existing tax schemes like gasoline taxes, are often at a far higher level than current carbon prices, and can only significantly affect demand at such high levels. The timing for the inclusion of different sectors might thus vary across countries, and indeed does vary in the different schemes currently evolving. Additional criteria like transaction costs, implications for management accountability, and cultural preferences also need to be considered.

The level of awareness and public support for action to mitigate climate change differs across countries. This creates two basic choices. The first is to agree in international negotiations on a common level of ambition – the lowest common level – and comparable emissions reduction targets. The attempt to be more ambitious failed in the case of the Kyoto when the US Congress did not ratify the protocol negotiated by their delegation. The second choice is for governments to commit to emissions reduction targets at different levels of ambition reflecting the level of domestic awareness and support for climate policy.

What would be the implications of these two options for emissions trading? If countries pursue climate policy at similar levels of ambition, then the resulting carbon prices are likely to be similar. With similar carbon prices, the net financial transfer between countries would be limited. The financial transfer would only increase if unexpected events, like a nuclear outage required a shift to fossil fuel based generation, changing demand for emissions allowances in one country. Trade provides the flexibility to respond to unforeseen events, and would otherwise not create large financial transfers between countries.

If countries pursue climate policy at different levels of ambition, the carbon price in the ambitious countries would initially be higher. The use of trading enables firms in these ambitious countries to buy allowances from governments or firms in less ambitious countries until the carbon price is equalised. These financial transfers could be large. Anticipating the transfers, developed countries are reluctant to commit to a more stringent target than other developed countries. This would be a drawback of emissions trading among developed countries with different levels of ambition for their climate policy.

A framework that allows countries to pursue an ambitious climate policy that includes high carbon prices is preferable to waiting for a global harmonised approach. It will accelerate the development of lower-carbon technologies, infrastructure and regulatory frameworks. The countries might benefit from reduced dependency on imported fossil fuels, and their firms could become international first movers for technology and services solutions. Once other countries also increase their level of ambition, their implementation of climate policies will be faster because it can build on existing experience with policy instruments and technologies. Eventually, perhaps by 2020, the levels of ambition might converge and then allow for close linking of the schemes.

Developing countries are part of any solution to climate change. With growing emissions levels and the increasing impact of climate change there is both the need and the motivation to engage these countries in active climate policy. Currently the Clean Development Mechanism represents the main channel for financial transfers from developed countries to support the decarbonisation effort of developing countries. Firms in developed countries invest in projects in developing countries and the emissions reductions they achieve are credited against the emissions of the firms in their home countries. CDM projects have been developed across a range of countries and technologies, and have created stakeholders and expertise in developing countries.

Expanding the scale and scope of CDM is often discussed. In principle a common carbon price for CDM credits is economically efficient because it pays the same price for every avoided ton of carbon emissions and ensures the lowest cost projects are selected. But the approach also inflates the required funding stream because projects with lower costs still receive the full carbon price. This will probably limit political support and the volume of total emissions reductions achieved. The funding requirement is further increased as energy is often subsidised in developing countries, thus increasing the demand and reducing incentives for energy efficiency measures and behaviour. This points to a possible evolution of CDM: the financial transfers could be used to support climate policies in developing countries.

The discussion suggests that carbon pricing might be applied at different levels across countries and sectors during the initial years of climate policy. This raises the question in chapter 5 if **internationally differing carbon prices can be handled for the next decade**. The main concern that needs to be analysed and addressed is whether carbon price differentials would result in leakage of emissions from the relocation of production to other countries rather than emissions reductions?

The question cannot be answered from an economy wide perspective because across 98-99% of economic activities, carbon price differentials will not give rise to competitive distortions or leakage of emissions. Only 24 sub-sectors demonstrate cost increases from direct carbon emissions or carbon related electricity price increases that are significant. Transport costs and risks, customer relationships, tailored products and many other factors further reduce the impact of carbon price differentials for these sectors and suggest that leakage is only of concern for some of these sectors.

For sectors where leakage concerns remain, governments can choose from several options to create a level playing field. Allowances can be allocated for free to emitters or direct subsidies can be provided via state aid. This approach can protect the profits of firms. However, some firms might chose to close or relocate their production and sell the allowances they received for free. Simple provision of subsidies does not address leakage concerns, and thus has to be conditional on the continued operation of firms. But this conditionality creates perverse incentives, and reduces the effectiveness of the scheme.

In the European context direct public subsidies, so called state aid, for investment and re-investment in exposed sectors is discussed as a more targeted approach of providing subsidies. State aid is in the European institutional design subject to a technical evaluation process and might offer an opportunity to avoid the politicised debate about free allowance allocation and thus better limit the support to installations where leakage is really of concern.

Border adjustment requires that firms are exposed to the full cost of carbon in order to be compatible with rules of the World Trade Organisation. Several different designs are discussed. One possibility is to require importers into a region to pay a tariff that corresponds to the carbon costs of producing the commodity, (e.g. basic steel or clinker), with the best available technology. The political sensitivity of trade measures requires careful handling to avoid undermining cooperative efforts across countries and to reflect the common but differentiated nature of climate responsibilities. An international process with a clear focus on solutions to leakage concerns would be necessary to ensure transparency and to build trust.

Government-led sectoral agreements could focus on implementing carbon pricing for a specific sector, rather than on an economy-wide scale. Sectoral agreements to deliver the full carbon price are, however, technically and politically complex. It might be preferable not to burden discussions on sectoral approaches with the difficult topic of leakage and underlying competitiveness issues, so as to allow sectoral approaches to focus on effective international cooperation to share best practice, technology and policy implementation.

In summary, together with appropriate regulation and technology policy, carbon pricing is an essential component of any effective climate policy. It can be implemented as a tax or emissions trading scheme, and, with appropriate design, can deliver a robust low-carbon investment framework. This framework must provide a clear trajectory for domestic emissions to allow policy makers to monitor and manage the implementation of climate policy and to reduce uncertainty for the private sector about future market opportunities. The commitment to domestic emissions reductions and the different emphasis countries put on carbon pricing relative to technology policy and direct regulation might initially result in differing carbon price levels across sectors and countries. Despite the lively debate on potential emissions leakage from such asymmetric carbon prices, the risk would be confined to a few carbon intensive commodities. Tailored policy instruments are available to address leakage concerns on a commodity by commodity basis. Eventually common technologies and shared levels of ambition to pursue climate policy will drive carbon prices to similar levels or, if schemes are eventually linked, to the same level. Carbon pricing also creates revenue streams that can be efficiently recycled to reduce distortionary taxes, accelerate low carbon-innovation and to compensate the disproportional impact on poorer households in developed and even more so in developing countries.

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[11] Demand elasticity for steel is assumed to be in the range 0.1-1.6 and for cement in the range (0.3-2). Carbon efficiency improvements at 20Euro/t CO_2 are expected in the range of 5-20% for steel and 15-30% for cement. Product prices are 350 and 76 Euro/t for basic steel and cement respectively.

[12] See Sijm, J. P. M., K. Neuhoff and Y. Chen (2006). "CO2 cost pass through and windfall profits in the power sector." Climate Policy **6**(1)., Matthes, F. (2007). Zuteilungsgesetz 2008-2012 für den EU-Emissionshandel. Stellungnahme zu den Fragenkatalogen der Fraktionen CDU/CSU, SPD, FDP, DIE LINKE sowie BÜNDNIS 90/DIE GRÜNEN zur Anhörung des Ausschusses für Umwelt, Naturschutz und Reaktorsicherheit des Deutschen Bundestages, Berlin.

[13] For analysis of the cement sector see Walker, N. and M. Richardson (2006). Developing national standards for durability, performance and environmental sustainability of concrete: an Irish case study illustrating the potential for 'win-win', UCD working paper. and for industry reported pass through McKinsey & Company Ecofys (2006). EU ETS Review. Report on International Competitiveness.

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[15] Cornwall, A. and J. Creedy (1996). "Carbon Taxation, Prices and Inequality in Australia." Fiscal Studes **17** (3): 21-38.; Labandeira, X. and J. Labeaga (1999). "Combining Input-output analysis and Mirco-simulation to assess the effects of Carbon taxation on Spanish Households." Fiscal Studies **20** (3): 305-320.; Smith, S. (1992). "The distributional consequences of taxes on Energy and the Carbon Content of Fuels." European Economy **Special Edition 1 (1992)**.; Symons, E., J. Proops and G. Gay (1994). "Carbon Taxes, consumer demand and Carbon Dioxide emissions: A simulation Analysis for the UK." Fiscal Studies **15** (2): 19-43.; Symons, E., S. Speck and J. Proops (2002). "The distributional effects of Carbon and Energy taxes: the cases of France, Spain, Italy, Germany and the UK." European Environment Agency **12**: 200-212.; Wier, M., K. Birr-Pedersen, H. Jacobsen and J. Klok (2005). "Are CO2 taxes regressive? Evidence from the Danish Experience." Ecological Economics **52**: 239-251.

[16] Rather than current income, some studies also compare cost increases to lifetime measures Metcalf, G. (1999). "A distributional analysis of Green Tax Reforms." National Tax Journal **52**(4): 655-682.; Poterba, J. M. (1991). Tax policy to combat global warming: on designing a carbon tax. Global Warming: Economic Policy Responses to Global Warming. R. Dornbusch and J. M. Poterba. Cambridge, MA., MIT Press. or total expenditure (Wier, M., K. Birr-Pedersen, H. Jacobsen and J. Klok (2005). "Are CO2 taxes regressive? Evidence from the Danish Experience." Ecological Economics **52**: 239-251..

[17] One approach currently discussed in the UK is to grant personal carbon credits to every consumer. This results in a de-facto lump-sum transfer, which can ensure that poor consumers are not disadvantaged under carbon pricing. This can also offer additional benefits by improving information and rising awareness on carbon emissions, but risks high transaction costs.

[18] Margolis, R. M. and D. M. Kammen (1999). "Evidence of under-investment in energy R&D in the United States and the impact of Federal policy." Energy Policy **27**(575-584). estimate that private returns on R&D across various sectors are between 20-30% while social rates of return are around 50%. In sectors where markets are influenced by regulation, additional risk exists that governments adjust regulation after successful innovations, such that investors will not capture the full benefit Grubb, M. J. (2004). "Technology Innovation and Climate Change Policy: An Overview of Issue and Options." Keio Economic Studies **41**(2): 103-132.

[19] Lev, B. (2004). "Sharpening the Intangibles' Edge." Harvard Business Review **June 2004**: 109-116. observed among companies that are members of the industrial research institute that they reduced the allocation of R&D funds to basic research every year from 1993 to 2003, in favour of modifications and extensions of current products.

[20] See for example IEA technology platforms on biofuels, photovoltaics or electricity networks (http://ec.europa.eu/energy/green-paper-energy/index_en.htm) or Asian Pacific Partnership (http://www.asiapacificpartnership.org/).

[21] See Neuhoff, K. (2005). "Large-Scale Deployment of Renewables for Electricity Generation." Oxford Review of Economic Policy **21**(1): 88-110. for more detailed discussion and Irwin, D. and P. Klenow (1994). "Learning-by-doing spillovers in the semiconductor industry." Journal of Political Economy **102**: 1200-1227. for the example of the semiconductor industry.

[22] In 1990 the penalty was $2000 and escalates at the rate of inflation Solomon, B. (1995). "Global CO_2 emissions trading: Early lessons from the U.S. acid rain program." Climatic Change **30**(1): 75-96..

[23] About 10 mio t of SO_2 emissions are covered by the trading scheme, with prices moving between 270-850 $/short ton. Thus the value of allowances, largely distributed for free, is in the order of $2.7–8.5 billion. In contrast, the European Union Emissions Trading Scheme covers about 2 billion tonnes of CO_2 emissions, which at a price of 20 €/tCO_2 value €40 billion.

[24] The Federation of German industry had signed in March 1996 with the German environment and industry ministry sector targets for emissions reductions by 2005 relative to 1990 levels. An UNFCCC report on the in-depth review of the second national communication of Germany, 24.8.1999 noted "that in nearly all cases the divergence between the commitment and BAU forecast is small" while "A similar pattern emerges for all of the agreements studied with a significant part of their targets having already been achieved by 1996." UNFCC (1999). Report on the In-depth Review on the Second National Communication of Germany: FCCC/IDR.2/DEU 24

[25] See also Morgenstern, R. and W. Pizer (2007). Reality Check: The Nature and Performance of Voluntary Environmental Programs in the United States, Europe, and Japan. Washington, DC: Resources for the Future Press.

[26] The Joint Implementation Supervisory Committee (JISC), under the authority and guidance of the COP/MOP, inter alia, supervises the verification procedure defined in paragraphs 30-45 of the JI guidelines. http://ji.unfccc.int/Sup_Committee/index.html To avoid double accounting, the project host country has to reduce its cap by the amount of JI credits that have been granted. The benefit for host countries are not emissions reductions, but co-benefits like technology transfer, improvement of energy infrastructure and investment flows.

[27] The existing rules create a "prisoner's dilemma where each individual Member State recognizes the collective interest to set restrictive caps for optimal reduction of emissions in the EU, but also has an interest to maximize the national cap" The Impact Assessment Accompanying document to the Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC, COM (2008) 16 final. SEC (2008) 53, Brussels, 23.1.2008.

[28] Where Member States envisaged investing in CDM projects or buying Assigned Units from countries like Russia, the Commission required evidence that these expenditures were reflected in national budgets.

[29] See Harrison, D. J., D. B. Radov and (2002). Evaluation of Alternative Initial Allocation Mechanisms in a European Union Greenhouse Gas Emissions Allowance Trading Schemes. NERA report to DG Environment, European Commission, NERA.; Neuhoff, K., K. Rogge, J. Schleich, J. Sijm, A. Tuerk, C. Kettner, N. Walker, M. Åhman, R. Betz, J. Cludius, F. Ferrario, K. Holmgren, G. Pal, M. Grubb and F. Matthes (2006). " Implications of announced Phase 2 National Allocation Plans for the EU ETS." Climate Policy **6**(5): 411-422.; Matthes, F., V. Graichen and J. Repenning (2005). The environmental effectiveness and economic efficiency of the European Union Emissions Trading Scheme: Structural aspects of allocation. WWF, Oeko Institute. Ellerman, D. (2006). New Entrant and Closure Provisions: How do they distort?, Massachusetts Institute of Technology: Center for Energy and Environmental Policy Research.

[30] See also Böhringer, C. and A. Lange (2005). "On the design of optimal grandfathering schemes for emission allowances." European Economic Review **49**(8): 2041-2055

[31] See Colombier, M. and K. Neuhoff (forthcoming). "Can sectoral agreements and output based allocation address leakage? ." Environmental Policy and Law. for a discussion of the distortions induced by benchmarks and Walker, N. and M. Richardson (2006). Developing national standards for durability, performance and environmental sustainability of concrete: an Irish case study illustrating the potential for 'win-win', UCD working paper. for a discussion of options to reduce carbon intensity at the example of cement.

[32] To address this concern in the power sector, some National Allocation Plans contain transfer provisions. The free allowances that an existing plant A would have received can be transferred to a new plant B. Thus the disincentive to close plant A has been reduced from the high level of free allowance allocation of plant A to the lower level of forgone free allowance allocation of the more efficient new entrant B. With the use benchmarks for the allocation to plants, such transfer provisions lost their relevance.

[33] Åhman, M., Holmgren, K., 2006. Harmonising New Entrant Allocation in the Nordic Energy Sectors: Current Principles and Options for EU ETS Phase II. IVL Swedish Environmental Research Institute, Stockholm, Sweden. Matthes, F., Graichen, V., Harthan, R.O., Repenning, J., 2006. Auswirkung verschiedener Allokationsregeln auf Investitionen im Strommarkt, www.oeko.de. Neuhoff, K., Ferrario, F., Grubb, M., Gabel, E., Keats, K., 2006a. Emissions projections 2008–2012 versus National Allocation Plans II. Climate Policy 6(4), 395–410.

[34] A discussion of experiences from auctions across different sectors can be found, for example, in Klemperer, P. (2002). "What Really Matters in Auction Design." Journal of Economic Perspectives **16**(1): 169-189. or Jansen (2004).

[35] For calculations in the USA context see Burtraw, D., K. Palmer and D. Kahn (2005). "Allocation of CO2 Emissions Allowances in the Regional Greenhouse Gas Cap-and-Trade Program." RFF Discussion Paper(05-25).

[36] Survey by Point Carbon 2007, www.pointcarbon.com

[37] See for example Newell, R. and W. Pizer (2003). "Regulating Stock Externalities Under Uncertainty." Journal of Environmental Economics and Management **45**: 416–432.

[38] For an application to climate policy see for example Pitzer, W. (2005). Climate Policy Design under Uncertainty, RFF discussion paper 05-44.

[39] Historic data: European Commission (2006). Energy and Transport in Figures 2006. European Union. Projections for 20% domestic emissions reductions by 2020 and 80% by 2050. CCS fraction 2% in 2020, efficiency 85% in 2020 and 80% in 2050.

[40] A survey among utilities at the end of 2005 and start of 2006 suggested that business required 'courage' to make investments where the return is dependent on there being a carbon price in 2013. Hamilton, K. and M. Kenber (2006). Business Views on International Climate and Energy Policy, UK Business Council for Sustainable Energy.

[41] Yang, M. and W. Blyth (2007). Modeling Investment Risks and Uncertainties with Real Options Approach, IEA working paper series LTO/2007/WP 01. illustrate how the real option of waiting for clarity on climate policy instruments can delay investment in low-carbon power generation technologies.

[42] Pershing, J. and F. Tudela (2004). A Long-Term Target: Framing the Climate Effort. Beyond Kyoto: Advancing the international effort against climate change, PEW Centre on Global Climate Change. discuss the appropriate formulation of such a targets, e.g. as global temperature increase, as CO_2 concentration or as CO_2 emissions. Defining targets that are most sensitive to human activity (e.g. annual emissions) avoids uncertainty that results if the impact of human activity on more indirect systems has to be analysed (like CO_2 concentration or global temperature). Reducing uncertainties then reduces "opportunities for discord and delay".

[43] Pizer, W. and R. Kopp (2005). Calculating the Costs of Environmental Regulation. Handbook of Environmental Economics. K. Goran-Maler and J. Vincent. Amsterdam, Elsevier. argue that the current evidence is not conclusive.

[44] Policies used to deliver the target levels have to allow for this flexibility. For example, cap and trade schemes should not commit to allocating large shares of free allowances over long time frames. This would limit the level to which the cap could be tightened. In addition, if large shares of allowances are allocated for free and the carbon price rises, then the wealth transfer to the recipients also increases. This might not be politically sustainable and could result in changes in to the scheme.

[45] The two new Member States Bulgaria and Romania were not yet included in the analysis

[46] Glienke surveyd 55 German companies in spring of 2005. 36 list uncertainty about future allocation as important or very important for their emissions trading strategy (ISI –Fraunhofer institute, Karlsruhe (private communication)

[47] Schemes that heavily rely on banking of allowances might create a biased in favour of rich organisations and countries. Their existing wealth increases the ability to bank and the willingness to take the risk of uncertain future returns of such banking, and then reap the future benefits.

[48] At the same time banking in the presence of uncertainty about future climate policy reduces the level of today's allowance prices. This is, because with banking some market participants have to buy allowances and store the allowance for future use. If future allowance prices are uncertain, then market participants require a higher risk premium for investing capital in buying allowances today. This risk premium does not apply, if the investors can use the banked allowances as a hedge for other carbon related risk exposure. They will only buy allowances if the allowance price is sufficiently low today to allow for a recovery of the risk premium. Thus increased uncertainty about future allowance prices will result in lower current allowance prices. Regulatory risk can thus distort efficient emissions reductions.

[49] To ensure that investors could contribute to investment in new energy technologies, World Bank (2006). Clean Energy and Development: Towards an Investment Framework. Environmentally and Socially Sustainable Development Vice Presidency, World Bank. argues that subsequent revenue streams would need to be collateralized.

[50] Along a similar line in the international context Aldy, J. E., R. Baron and L. Tubiana (2004). Addressing Cost: The Political Economy of Climate Change. Beyond Kyoto: Advancing the international effort against climate change, PEW Center on Global Climate Change. argue “with more countries participating, emissions allowance prices would be subject to less uncertainty and variability.”

[51] See Grubb, M., J. Köhler and D. Anderson (2002). "Induced technical change in energy and environmental modelling: analytical approaches and policy implications." Ann. Rev. Energy Environ. **27**: 271-308, Rosendahl, K. (2004). "Cost-effective environmental policy: implications of induced technological change." Journal of Environmental Economics and Management **48**(3): 1099-1121. Sijm, J. P. M., O. J. Kuik, M. Patel, V. Oikonomou, E. Worrell, P. Lako, E. Annevelink, G. J. Nabuurs and H. W. Elbersen (2004). Spillovers of Climate Policy An assessment of the incidence of carbon leakage and induced technological change due to CO_2 abatement measures. Netherlands Research Programme on Climate Change Scientific Assessment and Policy Analysis, ECN.

[52] Based on Proposal for a Decision of the European Parliament and the council on the effort of Member States to reduce their greenhouse gas emissions to meet the Community’s greenhouse gas emissions reduction commitments up to 2020, presented by the Commission in January 2008.

[53] Several parallels are striking (i) importance of accurate public available information on the impact on the live of slaves to raise public awareness and initial attempts by pro-slavery movement to distort truth (ii) the role of discounting of the value of slave lives (iii) gradually increasing level of ambition to tackle slavery, perhaps reflected initial penalties for slave trade from £100/head (1807) towards death penalties for traders (1827) (iv) the role of compensation of previous slave owners, at the account of £20 mio in 1838. For a summary on abolition see [http://www.history.ac.uk/ihr/Focus/Slavery/articles/walvin.html]

[54] See Ashton, J. and X. Wang (2004). Equity and Climate: In Principle and Practice. Beyond Kyoto: Advancing the international effort against climate change, PEW Center on Global Climate Change.

[55] Philibert, C. and J. Reinaud (2004). Emissions trading: taking stock and looking forward. COM/ENV/EPOC/IEA/SLT, OECD/IEA. argue that “emissions trading might be the centrepiece for international efforts to build a global and comprehensive greenhouse gas mitigation regime”.

[56] In a speech given in Kyoto, 20 September 2007, Mark Lynas, New Statesman

[57] Bodansky, D. (2004). Climate Commitments: Assessing the Options. Beyond Kyoto: Advancing the international effort against climate change, PEW Center on Global Climate Change. argues that commitment “provides a signal to the market that helps drive changes in private behaviour.”

[58] http://www.chicagoclimatex.com/index.jsf

[59] CDM: article 12, JI: article 3 of the United Nations (1998). Kyoto Protocol to the United Nations Framework convention on climate change.

[60] Maastricht-criteria: European Union (1992). Maastricht Treaty, European Union.

[61] Webster, M., S. Paltsev and J. Reilly (2006). The Value of Emissions Trading. MIT Joint Program on the Science and Policy of Global Change. investigate the value of international emissions trading and argue that the benefits calculated for international emissions trading stem largely from the burden redistribution effect. The negative impact of emissions trading on the balance of payments could outweigh the benefits from hedging and identifying least cost abatement options.

[62] IEA (2004). World Energy Outlook 2004. Paris, OECD/IEA.

[63] Michaelowa, A., S. Butzengeiger and M. Jung (2005). Graduation and Deepening: An Ambitious Post-2012 Climate Policy Scenario. International Environmental Agreements: Politics, Law and Economics.

[64] As of 19.11.2007 the volume of expected certified emissions reductions from registered projects was 1.08 billion, with more than one billion CERs associated with projects in the project pipeline. http://cdm.unfccc.int

[65] http://cdm.unfccc.int.

[66] The limit is defined as 3% of each Member State's emissions from sources outside the ETS in the year 2005, in addition installations covered by the European Union Emissions Trading Scheme can use Kyoto credits where they did not meat their limit for the period 2008-2012 (about 13% averaged across member sates).

[67] See Bodansky, D., S. Cou and C. Jorge-Tresolini (2004). International Climate Efforts Beyonod 2012: A Survey of Approaches. Advancing The International Effort Against Climate Change, Pew Center on Global Climate Change. for a discussion of a variety of other internationa co-operation initiatives.

[68] IEA (2004). World Energy Outlook 2004. Paris, OECD/IEA.

[69] This assumes the typical shape of marginal abatement cost curves is approximated with a quadratic function.

[70] Samaniego, J. and C. Figueres (2002). Evolving to a Sector Based Clean Development Mechanism. Options for protecting the climate. K. Baumert. Washington, DC, World Resource Institute. discuss the extension of CDM to sectoral CDM in order to cover a wider range of projects. Drawing on work by Philibert, C. and J. Pershing (2001). "Considering the Options: Climate Targets for All Countries." Climate Policy **1**: 211-227. they argue that "S-CDM does not operate as a *sectoral target*", they also discuss the option that an "internal clearinghouse mechanism could discover the average reduction cost over the whole [sectoral CDM] project."

[71] Shiell, L. (2003). "Equity and efficiency in international markets for pollution permits." Journal of Environmental Economics and Management **46**: 38-51. shows in a formal model that the resulting more stringent targets can represent a Pareto improvement.

[72] Heller, T. C. and P. R. Shukla (2004). Development and Climate: Engaging Developing Countries. Beyond Kyoto: Advancing the international effort against climate change, PEW Center on Global Climate Change. argue "For some time to come developing countries emissions will continue to be derivatives of other development choices, and can be better managed if recognized as such." They suggest a way beyond the present difficulties of North-South collaboration would be to seek climate-favouring activities that emerge as ancillary benefits of sound development programs. However, development and climate change objectives are not necessarily aligned. Pan, J., X. Zhu and Y. Chen (2005). "Fulfilling basic development needs with low emissions: China's challenges and opportunities for building a post-2012 climate regime." Governing Climate: The Struggle for a Global Framework beyond Kyoto: 89-108. illustrate at the Chinese example how increasing living standards is expected to increase energy demand and CO_2 emissions.

[73] See for example Ellis, J. and M. Bosi (2005). Exploring Options for "Sectoral Crediting Mechanisms". OECD Environment Directorate, IEA. Paris, OECD/IEA..

[74] Winkler, H., B. Brouns and S. Kartha (2006). "Future mitigation commitments: differentiating among non-Annex I countries." Climate Policy **5**(5): 469-486. suggest approaches to differentiate among non-Annex I countries for future mitigation commitments. Michaelowa, A., S. Butzengeiger and M. Jung (2005). Graduation and Deepening: An Ambitious Post-2012 Climate Policy Scenario. International Environmental Agreements: Politics, Law and Economics. suggest that developing countries that exceed a threshold, defined by GDP per capita and emissions, gradually become responsible for mitigation efforts.

[75] See related discussion about pollution haven hypothesis, e.g. Copeland, B. R. and M. S. Taylor (1994). "North-South Trade and the Environment." Quarterly Journal of Economics **109**(2): 755-787..

[76] As confirmed by a comparison of the share of different manufacturing activities in the UK against the European average Hourcade, J.-C., D. Demailly, K. Neuhoff and M. Sato (2007). Differentiation and dynamics of EU ETS competitiveness impacts. EU ETS Competitiveness Workstream Interim Report, Climate Strategies

[77] Higher carbon prices or more carbon-intensive electricity production scale the value at stake in figure 5.1 linearly – 20% higher prices increase the value at stake by 20%.

[78] E = T/S = (Exports+Imports)/(Demand+Imports) = (Exports+Imports)/(Production+Exports)

[79]See Kuik, O. and R. Gerlagh (2003). "Trade Liberalization and carbon Leakage." The Energy Journal **24**(3): 97-120.

[80] Base case with demand elasticity of -.6 and Armington trade elasticity of 5. Carbon intensity of BAT assumed to be 1.81 t CO_2/t steel. Assumption that steel producers pass carbon price to product price. Increased demand elasticity -1 and Armington elasticity 10.

[81] A second major steel production process is based on the electric arc furnace (EAF). While carbon pricing has a larger impact on the electricity costs of this process, the total cost increase is smaller because of the reduced process emissions. This can be easily explained – the main input is steel scrap. EAF steel production can be classified as steel recycling that is limited by availability of scrap steel.

[82] Bohringer, C. and A. Lange (2005). "On the design of optimal grandfathering schemes for emission allowances." European Economic Review **49**(8): 2041-2055.

[83] Demailly, D. and P. Quirion (2006). "CO2 abatement, competitiveness and leakage in the European cement industry under the EU ETS: Grandfathering vs. output-based allocation." Climate Policy **6**(1).

[84] Such requirements might be perceived as a trade barrier under rules of the World Trade Organisation, see discussions on labelling or efficiency standards to support the use of low-carbon products Charnovitz, S. (2004). Trade and Climate: Potential Conflicts and Synergies. Beyond Kyoto: Advancing the international effort against climate change, PEW Center on Global Climate Change..

[85] Ellerman, D. (2006). New Entrant and Closure Provisions: How do they distort?, Massachusetts Institute of Technology: Center for Energy and Environmental Policy Research..

Matthes, F., V. Graichen and J. Repenning (2005). The environmental effectiveness and economic efficiency of the European Union Emissions Trading Scheme: Structural aspects of allocation. WWF, Oeko Institute..

[86] Philibert, C. (2004). Technology Innovation, Development and Diffusion. OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT. or IISI (2007). A policy to reduce steel-related greenhouse gas emissions, IISI Policy Statement.

[87] See work of Baron, R., J. Reinaud, M. Genasci and C. Philibert (2007). Sectoral Approached to Greenhouse Gas Mitigation: Exploring Issues for Heavy Industry. IEA/OECD..

[88] With a trading scheme for one sector, all installations would likely use similar technology and more importantly, would depend on a similar technology innovation to reduce emissions. Success of any one innovation is always uncertain, and therefore the sectoral target would have to be set rather leniently to ensure viability of the trading scheme even if innovation is delayed. With sectoral trading the main benefit of emissions trading schemes is thus lost: combining uncertainties of innovation and growth rates of many sectors to reduce the uncertainty about the aggregate emissions reduction opportunities. Obviously the sectoral scheme could be linked to an outside carbon market, often the CDM market is mentioned in this context. But if there is an expectation that such a market will provide a credible price signal that is widely shared, then this raises the question why there would be the need for a specific sectoral trading scheme.

[89] See Zhang, Z. X. (1998). "Greenhouse Gas Emissions Trading and the World Trading System." Journal of World Trade **32**(5): 219-239. For description of implementation at level of best available technology and discussion of WTO compatibility see Ismer, R. and K. Neuhoff (2007). "Border Tax Adjustments: A feasible way to support stringent emission trading." European Journal of Law and Economics **24**: 137–164., For simulation results in the cement case see Demailly, D. and P. Quirion (2006). Leakage from climate policies and border tax adjustment: Lessons from a geographic model of the cement industry, CIRED..

[90] Some proposals aim to compensate for average carbon intensities, or to differentiate based on the climate policy implemented by the trade partner. This would however discriminate against some foreign producers. Proponents argue that their approaches could be exempt from stringent WTO requirements if they are presented as a component of an international environmental agreement. While this is in theory possible, it is uncertain how a WTO panel would rule. The approach would therefore not offer the certainty required for investment choices. Also, if carbon prices continue to differ across regions, the leakage might not necessarily occur along the lines of signatures of the international environmental agreement, but along the lines of carbon price differentials. This illustrates that border adjustment is an economic, not a political instrument and should therefore also be implemented within the boundaries of economic rational defined by general WTO rules.