Translating model results into economic policies

Working Paper

RECIPE

THE ECONOMICS OF DECARBONISATION

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1 Introduction

Simulation results presented in the first two chapters illustrate potential developments of an energy and economic system. They offer a consistent framework to analyse a low-carbon transition, which is invaluable for a broader discussion: First, it enhances the credibility of the results, as the results in a simple model framework can be clearly explained and compared across models. While it is always possible to enhance the complexity of models to capture additional dimensions of reality, this often undermines the credibility of the results as it becomes increasingly difficult to test and interpret the results. Second, it captures interactions across sectors and fuel sources, and thus ensures that the budget and energy consumptions add up. Third, the quantification can help to clarify communication between stakeholders, by providing consistent numbers to all actors.

The modelling results from the first two chapters thus provide reference cases for potential future developments. This chapter aims to draw insights for policy design from these model results. The models do, however, ignore important factors that influence investment, innovation, production and consumption decisions. After all, managers and consumers make these decisions in a reality that is characterised by: incomplete information, uncertainty, limited trust in continuity or announced policy schemes, concerns about technology spillover, constrained access to capital, administrative barriers, and institutional mismatches. Decisions are made in processes that are not always fully rational, follow behavioural patterns, focus on a limited number of factors, and are frequently based on past experience.

Obviously, these factors need to be considered when designing and implementing policy instruments to deal with the real world. In this chapter, we will focus in particular on:

- The different drivers for investment decisions – and a set of policy instruments that can support companies, investors and consumers in shifting to energy-efficient and low-carbon technologies, products and activities (Section 2).
- Drivers for innovation and technology development – and a combination of tailored support for individual technologies and expectations of market opportunities to accelerate the development and diffusion of energy-efficient and low-carbon technologies (Section 3).
- Opportunities and constraints for a shift to low-carbon development trajectories in the South – and mechanisms that the North can use to support this shift (Section 4).

2 Low-carbon investment policy

Key messages for governments:

Low-hanging fruit of efficiency improvements can be captured at low cost with appropriate regulation and information, which point to options for more initial emission reductions

Initial carbon prices must be higher than projected by most models. Notably because investors take current prices as a strong indication of future prices.

There is an urgent need to commit to 30 % emission reductions in Europe by 2020, and to limit the use of CDM to small shares

Key messages for industry:

Take a comprehensive perspective on mitigation requirements to identify the need for action

Assess the implications for substitution and growth opportunities, looking beyond comparisons within a sector

Work with governments to assess the necessary institutional and regulatory changes for transition at a sectoral level (e.g. standards on clinker content in cement, building codes, power market design to accommodate large-scale renewables and infrastructure requirements)

2.1 Policy framework for low-carbon investments

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2.1.1 Translating model trajectory into policy objectives

The effects of climate change do not occur instantaneously. Instead, emissions and the associated climatic impacts accumulate over a number of years and even decades. Likewise, mitigation and adaptation responses to climate change require investment, diffusion of new technology, and adoption of new behavioural patterns, which will evolve over time and may only have an effect in the longer term. This puts emphasis on projecting future emissions and climate impacts, and identifying suitable policy responses. Several methodologies have been developed to pursue such projections.

Storylines and scenarios, as outlined for example in IPCC scenarios, aim to paint a picture of the future. The inclusion of different experts' input into our definition of the scenario aims to make our socio-economic system more representative. We aim to capture many of the dimensions of future real developments and interactions. However, one challenge of such a descriptive approach is that it makes it difficult to judge internal consistency and in particular, correctly describe development over time.

Simulation models offer the opportunity to create an internally consistent projection of the future. The main challenge for such a modelling approach is an inherent trade-off between complexity and transparency. Global economic models must simplify the world they represent with individual actions of all actors, strategies of all firms, and policies of all governments.

This creates a big challenge for modellers: how best to simplify the models to reduce complexity and enhance transparency, whilst still capturing and potentially even quantifying the important effects of the socio-economic system. Before interpreting model results, it must be considered whether, in the specific context of the specified model, the assumptions create an inherent bias. It is often preferable to have a simple model that provides an output with a known bias, than a complex model that is difficult to verify. The simple model with a known bias would only require an adjustment to the baseline prior to its interpretation, e.g. for policy advice.[1]

This section discusses three assumptions that are shared by most of the three models that are part of the RECIPE project, as well as most other macro-economic models. They are as follows:

Past investment decision were pursued by fully informed and rational agents and governments, and hence there is no low-hanging fruit of energy efficiency measures currently available.

Future investment decisions will be pursued by agents that have full information about the future, and trust in announced government policies.

There exists a backstop technology that can be deployed with certainty in the future.

In each case, we discuss how the optimal transmission trajectory and carbon price trajectory can be adjusted, if the corresponding assumption does not apply.

First, models assume all actors make economically optimal decisions. This also implies that past investment, operation and consumption decisions reflect optimal choices. However, empirical evidence (Jaffe et al, 2001) points to low or negative cost options for energy efficiency improvements, indicating that past choices were not necessarily optimal, possibly because of institutional and regulatory constraints. If targeted policies can capture some of these opportunities, then more ambitious emission reductions are possible during the early stages and the emission trajectory should decline more rapidly.

Second, in the models REMIND-R and WITCH, investors make investment choices which anticipate future market developments. This is an approach which ensures internal consistency of the model. However, experience from regulated markets suggests that investors discount government promises. If, as in these two models, governments initially pursue rather lax climate policies and policy stringency only increases over time, then real investors might not have confidence in such a policy trajectory. Rather than assuming more stringent future policies, caps and carbon prices, as predicted in the model, investors might use current policies as their best indicator for future frameworks. In order to demonstrate to investors a commitment to climate policy, governments need to pursue more ambitious policies right from the beginning. This will ensure that investors assume future climate policies will also be ambitious (cf. e.g. Helm E.A., 2003).

[1] This approach has, for example, become standard in the power sector. It is generally shared that some level of market power exists, that results in pricing above marginal variable costs – but modelling the price impact is virtually impossible. Therefore most modelling exercises simulate competitive equilibrium, and subsequent interpretation applies adjustments.

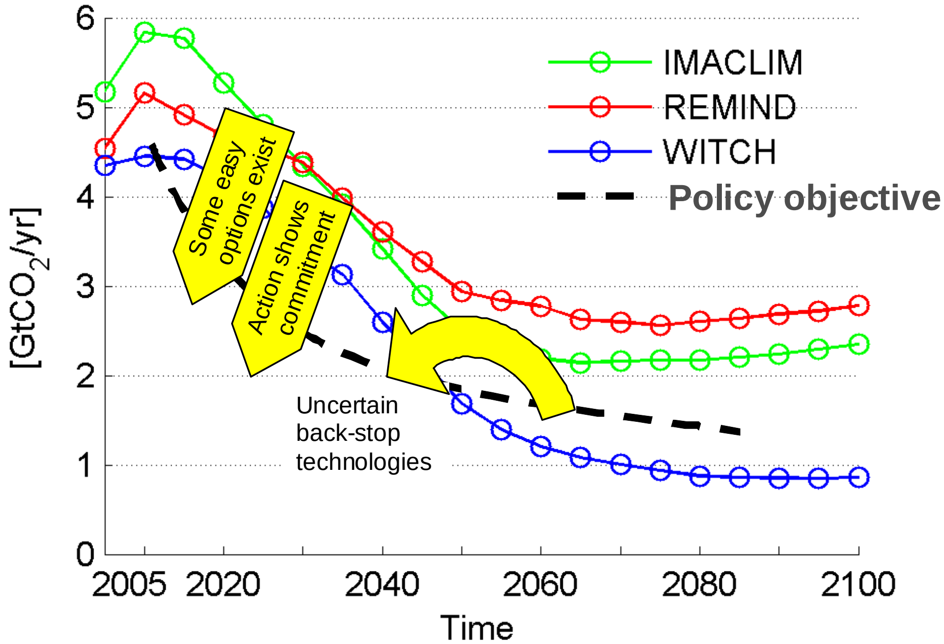

Figure 2-1: Optimal emission trajectories simulated in the RECIPE project. If policy focus can unlock cheap emission reduction options, if early actions are required to show commitment and if back-stop technologies are uncertain, then adjustments to these trajectories are necessary; this is indicated by the dashed line.

Third, all three models offer the opportunity to deploy large volumes of low-carbon technologies post-2050, and for the very low stabilisation scenarios REMIND-R uses sequestrated biomass emissions for a net reduction of CO_2 concentration in the atmosphere. It is uncertain whether sufficient volumes of, for example, biomass and geological storage sites are available. It is also not clear whether political and economic capability to pursue such policies will exist in a future world, in which the situation is desperate enough to aim for negative CO_2 emissions, if today's governments, acting in a robust geopolitical environment, struggle to find a global consensus. Should the very ambitious negative emission technologies turn out to be less successful than anticipated in such models, then stabilising CO_2 concentration will require quicker reduction of CO_2 emissions in the early years.

To keep open the option to achieve 'very low' stabilisation scenarios, it is necessary to pursue from the beginning 'very low' emission stabilisation pathways. As we are still learning about the climate system, this approach offers the opportunity to shift to more ambitious future emission reduction targets, should new information create the need and political power to do so. This obviously raises broader questions about how to weigh future benefits and risks against costs, and has received much attention in the context of the Stern Review (Stern, 2006).

Figure 2-1 is a summary of how emission trajectories must demonstrate more rapid declines in emissions for Europe in the initial years than those projected by the macro-economic models if one or several of a number of conditions applies. Firstly, low or negative-cost emissions reduction opportunities exist which are not taken into account by the models.

Secondly, investors judge future commitment to low-carbon policies according to today's government action. Thirdly, there is a risk that some of the back-stop technologies implemented in the model will not materialise.

2.1.2 Putting a price on carbon

This section touches on the reason for pricing carbon, the aspects to consider in choosing instruments to deliver a carbon price, and the level of prices that are likely to be necessary. The carbon price is only one component of the policy mix. Bodirsky et al. (2009) illustrated the need and opportunity for sector-specific policies, and tailored policies to enhance innovations are discussed in this working paper.

The economic case

The purpose of pricing carbon is to internalise carbon externalities, so as to increase the costs of carbon intensive activities. This creates the incentive for investment and operation decisions to become more carbon and energy efficient and for production and consumption choices to shift to low-carbon alternatives. In addition, carbon pricing creates opportunities for new low-carbon processes, products and services to compete with incumbent carbon and energy-intensive approaches.

Carbon pricing works effectively if the carbon price can feed through the value chain (Neuhoff, 2008). For example, if coal-powered stations must pay for carbon, market opportunities for low-carbon alternatives are improved. However, all the models have demonstrated that it is important to reduce overall energy demand – e.g. improve energy efficiency and shift to less energy-intensive processes and products. For the carbon price to incentivise a more efficient use of electricity, the carbon costs of power generation must be passed on in power prices. The European Union Emission Trading Scheme (EU ETS) has demonstrated how this has happened in the power sector. For other sectors, pricing decisions are less frequent and therefore fewer observation points are available, carbon costs constitute a lower share of the overall cost structure, and free allowance allocation creates even stronger distortions for operation and investment decisions. In addition, with international competition, the ability to pass through costs is reduced for some sectors. As a result of these reasons, price pass-through cannot be observed yet across all sectors, but will become important if carbon pricing is to deliver emission reductions.

Political economy of carbon pricing

It is easy to put a price on carbon in economic models, simply by requiring an additional variable and constraint. In political reality, this is more tricky; illustrated by the level of energy taxes different sectors pay. Industrial activities, which are most energy-intensive, such as the refining, chemical or steel industries, often face far lower energy taxes than other economic activities. Energy-intensive industries argue that higher tax levels would endanger their competitiveness relative to international competitors. This effect is illustrated in the following Figure 2-2. Overall tax levels paid by industry consumers of fuel are lower than for households. However, the rebate for light fuel oil is typically significantly higher than that for diesel. This can be explained by the fact that automotive diesel is supplied to the transport sector, which is providing a 'local' service, whereas the output of industrial activities is traded internationally and is therefore subject to international competition.

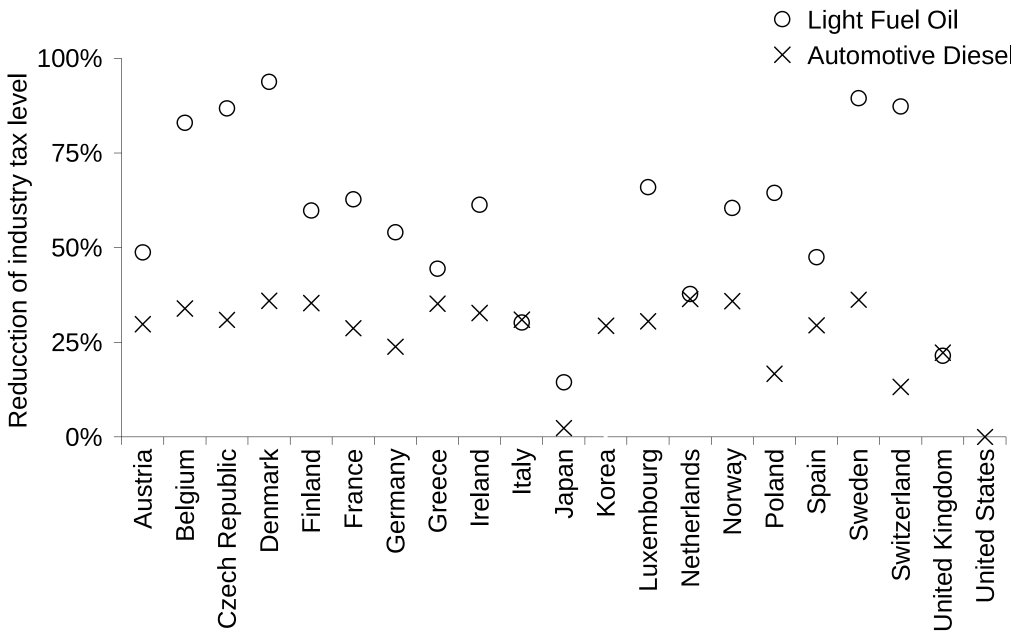

Figure 2-2: Reduction of tax levels for industry, relative to tax levels paid by households on light fuel oil and automotive diesel (based on IEA energy prices and taxes, 2005)

In a world where most countries have been struggling with energy import dependency, large rebates on energy taxes or, in other instances, even subsidies which energy-intensive users receive for their energy consumption, represent a perverse outcome. This distorts incentives for the sectors which have the biggest potential to respond to energy taxes by improving energy efficiency and developing more efficient processes and products (Brack, Grubb, and Windram, 2000).

Historic exemptions for energy-intensive sectors from energy taxes are the result of three factors. First, as energy-intensive industries have the biggest exposure to energy prices, they have the strongest interest in lobbying for exemptions. Second, historically strong ties of these industries with governments facilitate such lobbying activity in many countries. Third, energy-intensive export industries have always been effective in gaming governments against each other, using offers of lower energy prices or subsidies from one government to exert pressure and receive an even more privileged treatment in another country (Brander and Spencer, 1985).

Policymakers face the same challenges in implementing carbon pricing. In the EU ETS, industry lobbying achieved large-scale exemptions from auctioning of CO_2 allowances, and might continue to receive large shares of the allowances for free, up to 2020. Emerging US legislation and associated political discussions replicate this experience. Indeed, the main argument against auctioning of allowances is the concern about leakage of production and thus of emissions. The next section discusses the evidence base for this, and possible policy responses, in more detail.

Such industry pressure indicates that the political economy of carbon pricing is arguably the biggest challenge for any policy which aims to put a meaningful price on carbon. The evaluation of different policy instruments must therefore carefully consider their political viability.

Possible instruments for pricing carbon

There are two main policy options which are usually discussed: carbon taxes and emission trading. In principle, both instruments could deliver the same efficient outcome in a simple model world without uncertainty (Weitzman, 1974). In practice, many aspects must be considered to determine their relative merits. Obviously, the existence of a scheme such as the EU ETS is an important motivation to continue with the scheme. The subsequent discussion is therefore to a large extent relevant to the choice of instruments for sectors that are not yet covered by EU ETS; the work may also inform ongoing development of the scheme, and provide suggestions for detailed implementation.

Following on from the preceding discussions about the political viability of a policy instrument, the benefit of emission trading is that the carbon price emerges from the emission target and is not subject to direct political lobbying. However, conversely, the level of target setting and of free allowance allocation are exposed to political lobbying. Hence the real benefit of carbon trading might be the opportunity of creating inter-temporal consistency. Governments might be willing to commit to longer-term targets, and then use emission trading as the mechanism to ensure that the carbon price rises sufficiently to achieve those targets. Also, as argued in Section 4.2, future linking of emission trading schemes can create the expectation of similar future carbon prices, thus reducing leakage concerns and strengthening political viability.

Further aspects that need to be considered when choosing the appropriate policy instruments are transaction costs, which are typically higher for emission trading schemes than for taxation; they can build on existing administration and procedures. However, for example in the UK Carbon Reduction Commitment, a trading scheme for medium-sized electricity consumers has been specifically tailored so as to increase the transaction costs for the sector, to focus management attention on electricity consumption.[2] Thus it is expected that more internal and external – public – scrutiny will accelerate energy efficiency measures.

2.1.3 The effect of carbon pricing on investment decisions

In evaluating carbon taxes and cap and trade schemes, economists usually focus on their performance in the presence of uncertainty. The main impact of the schemes will be their influence on investment decisions.

Investment decisions are not pursued by homogeneous investors using an optimisation function; rather, they are taken by many different individuals and organisations. These actors respond to very different components of the climate policy package, as will be illustrated at the example of (i) a long-term strategic choice as pursued by the board of a company, or a pension fund that makes long-term investments, and (ii) decisions on individual projects and their financing.

[2] The CRC Energy Efficiency Scheme is being implemented in the UK as part of the Climate Change Act 2008, http://www.decc.gov.uk

Influencing strategic investors and corporate choices

Assume a company makes strategic choices on which sectors and products to focus R&D, manufacturing and marketing activities. This decision is informed by the size of the expected market and the expected performance relative to competitors. The size of the market determines the sales volume and the performance relative to competitors determines profitability. However, currently, the main focus of investors and corporations seems to be on performance relative to peers. Reduced costs, or better products, increase profit margins and allow capture of increased market share. Climate impacts are equally evaluated based on the relative performance of competitors, e.g. whether costs can be reduced by improving the efficiency of production. This is an important starting point for climate policy, but is unlikely to suffice to deliver the shift to low-carbon economic growth.

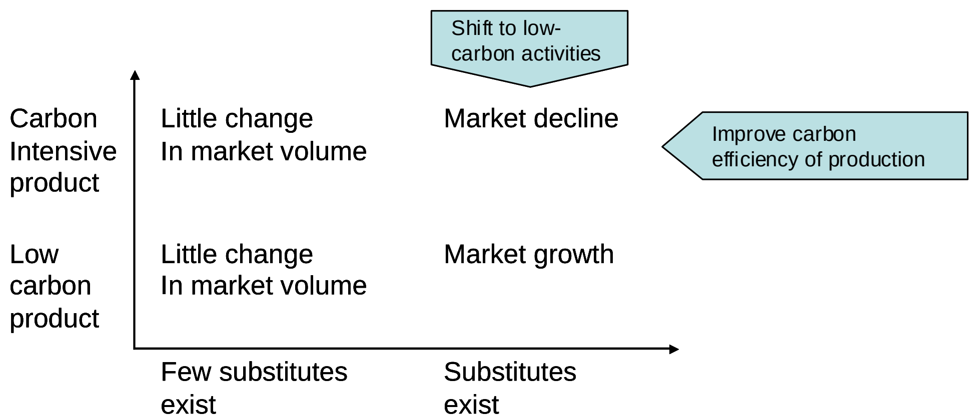

Figure 2-3: Effect of climate policy – impact for sector profitability

Figure 2-3 illustrates that climate policy can also contribute to emission reductions by shifting activities towards lower carbon products and services. This implies a decline in the demand for carbon-intensive products for which lower-carbon alternatives exist or are being developed. For this evaluation, it is insufficient to solely assess the carbon intensity during production; instead, emissions through the entire life-cycle must be considered. For example, even if a car producer uses efficient tools and produces few emissions during the production of the car, the future demand for cars will decline if they continue to rely on fossil fuels that become increasingly expensive with carbon pricing. The effect can also operate in reverse; for example, more carbon-intensive production of renewable energy technologies might be viable, if it resulted in lower carbon emissions over the lifetime of the installations.

Figure 2-3 therefore offers strategic investors a framework to make their long-term investment decisions. Obviously, there must be separate evaluation for each sector and production process. Thus it will allow funding to shift from carbon-intensive sectors and activities to low carbon alternatives, and will therefore contribute to low-carbon growth.

Unfortunately, little analytic work is available on the future market size of different products and commodities. It may be difficult, and probably not desirable, for governments to prescribe the roles which all products and services should play in the future. After all, the necessary information on efficiency improvement potential and on possible innovative low-carbon substitutes is available in the private sector. To consider the impacts of climate policy on market size of products and services for strategic investment choices, private actors require a simple and robust policy framework. The European Union can offer such a framework by committing to clear emission reduction targets that have to be delivered within Europe.

Investors and corporations will only shift their activities to low-carbon products and services, if this helps them to achieve their objectives, including profitability, market size and growth potential. The future carbon price will have to be high enough to compensate for possible higher input or technology costs of the low-carbon alternative. Given that input costs, for example for oil, gas or raw materials, are almost impossible to predict over long time frames, strategic investors do not expect – and might not even benefit from – a precise prediction of the long-term carbon price. For such investors, it is more important to have confidence that some mechanism exists to adjust future carbon prices in line with fossil fuel prices and technology costs so as to support the necessary shift to low-carbon products and services.

In this case, cap-and-trade schemes offer an advantage. They allow the carbon price to be responsive to costs and prices of other production factors, so as to ensure the emission target is not exceeded. Thus the trading scheme can increase the credibility of an emission target to which a government, or the EU, might commit.

A national or regional emission target can also be delivered with a carbon tax that is adjusted appropriately. But the political uncertainties associated with the tax adjustment process make this a less credible option.

The idea that demand for some carbon-intensive products might be declining does raise challenging questions. Countries have to be prepared for such developments, and provide and develop transition strategies, e.g. providing training for employees to shift to other sectors. Such measures are also important because they can dilute incumbent companies' political opposition to a low-carbon transition, by providing new opportunities for employees and communities.

Declining markets for carbon-intensive industries can result in excess production capacity with low or even negative profit margins. However, products such as cement or steel will not be replaced instantly, and significant production volumes will remain. For these products, it will be important to facilitate continued re-investment to enhance the energy- and carbon-efficiency of their production. A clearly defined and credibly implemented emissions trajectory can support this process, as it reduces uncertainty about the development of markets for carbon-intensive products, thus accelerating the adjustment of production capacity and ensuring more stable margins during the transition.

Facilitating low-carbon project investment

In contrast to strategic investment choices, for which relative performance and market size development matter, project investments are based on a business plan which must make specific assumptions on costs, prices and uncertainties. Project investments are usually pursued if the rate of return in the base case exceeds a hurdle rate. In addition, sensitivity analysis must confirm project performance even if some key parameters change. For investors in energy-efficient or low-carbon projects, the current carbon price is important to ensure the hurdle rate is reached. The risk of potentially low carbon prices affects the sensitivity analysis, and can thus prevent and or delay project investment.

The theoretical literature (Pizer, 2002) often assumes that carbon taxes provide a stable price signal, and are therefore potentially more suitable to facilitate project investment. However, so far the implementation of carbon taxes has been limited to selected sectors, mainly in Scandinavian countries. This does not provide robust evidence about the durability of a tax. Experiences from related policy instruments suggest that some caution is warranted. For example, in the USA, the main mechanisms to support renewable energy projects are production tax credits. They are negotiated – like any tax component – as part of the annual budget, and have thus been characterised by high volatility over time, and have contributed to a rather volatile investment trajectory. In a second example, China implemented an export tax for energy-intensive commodities, such as steel or cement. The country dropped this tax in March 2009, in response to the declining domestic and international demand for the respective commodities.

Emissions trading schemes have so far not presented a positive track record on their price stability. The price of allowances during the pilot trading period of EU ETS dropped to zero after two years of trading, when excess allocation became apparent. This result was unique to the pilot period, in which banking of allowances for later periods was prevented, to ensure the integrity of the scheme. However, the drop of allowances prices in the subsequent trading period (2009) below 10 Euro/t CO_2 has not contributed much to investor confidence in a robust carbon price signal. While the cap was more stringent for the period 2008-2012, the opportunity to use large volumes of CDM credits (off-sets) again reduced allowance scarcity in the market. In principle, expectations about future scarcity should encourage market participants to bank some allowances for the future. In practice, it is unclear whether investors are sufficiently confident about the evolution of the future carbon price to invest in CO_2 allowances. This effect is reinforced with a reduced willingness to take risks given the recent financial crisis and the limited level of ambition of future climate policy formulated in the EU 20 % emission reduction target for 2020. (Carbon Trust, 2009)

This shows that the implementation of a robust and credible carbon price signal is a challenging enterprise. Once a tax has been established for some time, it is more likely to remain in implementation. Likewise, the longer an emission trading scheme is in place, the better it will be understood by all actors, and the more likely it is that temporary excesses in supply of allowances will be banked by financial or other players. Thus it is important that a policy be maintained through initial difficulties until long-term credibility is achieved. This does, however, complicate policy implementation, because it requires clear differentiation between fundamental design flaws and temporary extreme market situations.

In the short-term, two options seem particularly suitable for European Member States to enhance the effectiveness of the carbon price signal delivered from the EU ETS:

- Declare more ambitious emission reductions to be delivered in Europe for 2020. This will encourage banking of allowances from today into the future, and thus push up today's price.
- Declare a reserve price that will be implemented in all auctions of EU ETS allowances. Thus, allowances will only enter the market from auctions if the carbon price exceeds the declare reserve price – and governments can avoid very low carbon prices without the need of direct intervention in the market.

2.1.4 The design of carbon pricing for Europe

Europe has decided to use emissions trading as the main mechanism to deliver a carbon price signal for large installations, and against the balance of different arguments that can be considered this seems to be a very reasonable choice.

If the objective is to demonstrate the viability of radical emission reductions to provide an example for developing countries and to create an environment to explore and diffuse low-carbon technologies, it is important to define and implement the emission trajectory that must be delivered within Europe.

This approach can be expanded in the future to trading schemes that are linked, as investors will merely have to develop a similar trajectory for the larger area which is covered by the linked scheme.

This does, however, raise questions about the viability of the EU ETS Directive, which envisages allowing for a large-scale use (5 % of emissions post-2012) of CDM credits, should the European target be strengthened from 20 % to 30 % emission reductions in the context of an international climate deal. It is difficult to predict what share of this larger opportunity for CDM credits will be used, as it depends on the policy development in other countries and the evolving methodology of defining CDM credits. Thus it creates significant uncertainties about the level of emission reductions which must be pursued within Europe. The low carbon prices in early 2009 highlight the risk for a robust carbon price signal that emerges: if too many CDM credits are allowed into the system, they eliminate scarcity within the system. Section 4.3 discusses how auction revenue and other mechanisms might provide a more suitable basis for resources to support developing countries in domestic climate action.

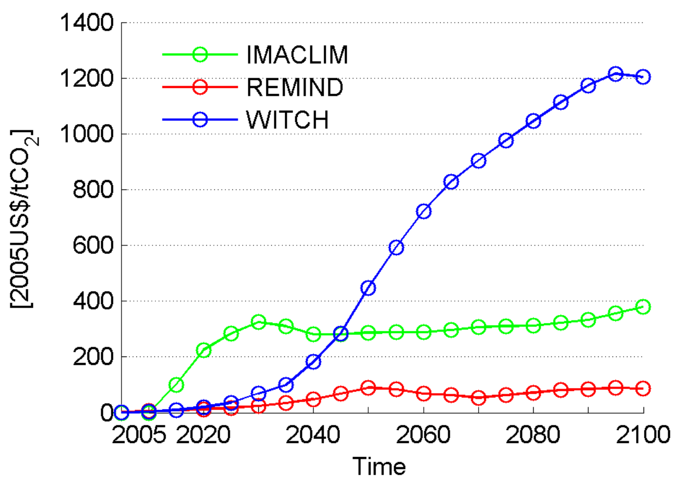

Figure 2-4: Carbon price trajectories from different models (policy scenario 450 ppm, C&C)

With all the modelling activity – one might expect clear statements about a likely carbon price to emerge from an optimal emission trajectory. Figure 2-4 illustrates the large discrepancies in carbon price trajectories resulting from the three models. These discrepancies are striking, as central input parameters such as population and GDP growth and fossil fuel resource base and cost have been carefully calibrated and thus many of the uncertainties that exist in reality have been removed for the model runs. The large discrepancies hint at difficulties that one might incur in a political process to set a carbon price. If even 'unbiased' model approaches result in large discrepancies, what is one to expect if, in reality, stakeholders select specific model calibrations to strengthen their lobby position for a specific price range. Emission trading with an emissions target defined by environmental necessity (e.g. a 2°C target) can reduce the need to determine the carbon price.

However, policy makers are responsive to observed carbon prices, as they are seen as one expression of the cost incurred by a scheme, and the effort exerted in an economy. Hence an assessment of the necessary carbon price remains important. In addition to the differences between the model runs that have already been discussed by Luderer et al. (2009), further aspects need to be considered when translating carbon prices that are projected by model runs to desired carbon price trajectories in reality (Figure 2-5).

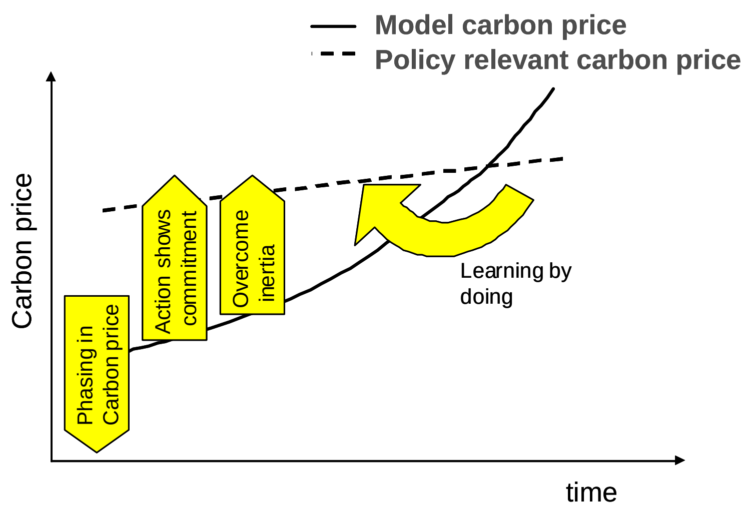

Figure 2-5: Adjustments to simulated carbon price trajectory to accommodate for (i) phasing in of carbon prices (ii) early actions to demonstrate commitments (iii) need to overcome inertia and (iv) externalities from learning by doing

First, it has sometimes been argued that initial carbon price levels should be chosen at a low level, so as to facilitate political acceptability. A gradual increase of the carbon price might be politically less challenging than a rapid carbon price increase; after all, one of the main impacts of carbon prices is the redistribution of rents between different stakeholder groups. This points to the opportunity to use some free allowance allocation, or recycling of auction or tax revenue, to mitigate the distributional impacts. Rather than relying on a gradual price increase, a scheme could use a complementary compensation scheme that is gradually phased out. Whichever approach is selected, it will require robust processes to allow for a subsequent strengthening of the price signal or phasing out of the free allowance allocation.

Second, even though both the REMIND-R and WITCH models project a gradually increasing carbon price, both succeed in shifting early investment choices. This is because investors in the model anticipate a future increase in the price of carbon. In contrast, the IMACLIM-R model assumes that investors do not believe in promises of more stringent future climate policy but assume the observed carbon price is the best indicator for any future carbon price. Therefore the carbon price projected by IMACLIM-R must be far higher in the initial years.

This result can be interpreted in two ways. REMIND-R and WITCH demonstrate that governments can shift investment towards low-carbon technologies if they can credibly commit to policies that deliver a rising carbon price. If governments cannot deliver sufficient commitment, and private sector actors take current carbon prices as the indicator for future carbon prices, governments must pursue policies which drastically increase current carbon prices, to ensure that investors choose low-carbon technologies.

The reality of the situation probably lies between these two extremes: governments should demonstrate all possible commitment – international agreements might play a central role in this context – to signal to the private sector that future carbon prices will rise sufficiently. The shortfall in full commitment can be compensated for by a carbon price that is somewhat higher than simulated in REMIND-R and WITCH. This higher carbon price also demonstrates government commitment.

Third, investment and consumption decisions are characterised by significant inertia: decision makers follow habit or an established protocols which focus on a few key parameters, rather than optimising a decision considering all parameters. To capture the attention of decision makers so as to trigger a change, it might be necessary to exaggerate the initial carbon price signal. Also, sector-specific policies can contribute to increased awareness and focus of decision makers (cf. Bodirsky et al., 2009).

Finally, many low-carbon and energy-efficient technologies are initially more expensive, but their costs are reduced with increased use. The WITCH and REMIND-R model both assume investors in technology can capture these learning benefits, e.g. using patents or their dominant position in the market, and therefore introduce the technologies to the market. As discussed in section 3, this is not always the case. In the case of clearly identifiable technologies, such as wind or solar power, governments can create subsidy schemes to support the initial learning following investment. In other sectors, for example the chemical industry, such a tailored technology policy might be more difficult to define. In this case, initially higher carbon prices might partially compensate for the limited ability of technology investors to appropriate learning benefits.

In summary, apart from the discussion on phasing in a carbon price, additional aspects considered when translating the model results into policy implications point to the benefits of higher initial carbon prices than are projected in the models. In principle, under a cap-and-trade scheme, higher prices should follow as a result of the envisaged emission trajectory. Indeed, the preceding discussion confirms the need for more ambitious emission reductions in the initial years than those suggested by simulation models.

Does this create additional economic costs relative to the model reference case? A more ambitious target in the initial years, capturing low-hanging fruit that is not reflected in the model reference case, can reduce economic costs. Obviously the policies required to capture the energy-efficiency measures might be politically challenging. In contrast, higher initial carbon prices to overcome inertia, to demonstrate government commitment, and to compensate for learning benefits where they are not internalised, increase costs, as they also result in some inefficient mitigation efforts. It is generally assumed that the net effect is negative, e.g. the imperfect implementation of policies in the real world will imply somewhat higher mitigation costs than calculated in models. This is a further argument for sector- and technology-specific policies which can target some of the market failures directly, thus limiting the extent to which initial carbon prices must exceed projected trajectories.

2.1.5 The role of sector-specific policies

Economic models putting a price on carbon – perhaps in combination with some technology policy – suffices to shift the economy to a low-carbon growth path. The sector analysis by Bodirsky et al. (2009) discussed additional barriers that might delay the shift to low-carbon growth:

Institutional and regulatory arrangements and market design are tailored for existing technologies and approaches, and can create barriers to change.

A change of economic and technological systems frequently requires a co-ordinated approach across a supply chain which consists of a large number of actors. Without co-ordination, either within a firm, within a clearly structured network of actors, or based on some public regulation, change might be delayed or hampered.

The models assume that markets function perfectly and the benefits of action are allocated to the actors. In reality, the principal- agent problems exists, implying that landlords do not benefit from insulating houses for their tenants, and employees might not benefit from reducing the energy bill of their company.

All these instances point to the need for complementary policies to facilitate a transition to low-carbon activities. Such policies can, however, take a multitude of shapes. They might adjust market design and regulation to allow for the use of other technologies. In other instances they can strongly influence actors' behaviour, e.g. if it is perceived to be too cumbersome to provide all necessary information to decision makers to capture their attention, governments will make explicit decisions on their behalf and e.g. abolish conventional light bulbs.

Regulation also facilitates a co-ordination of the supply chain to shift to a new product and to overcome the inertia of decision makers. Regulation largely encourages individuals to pursue profitable decisions. Using regulation without a carbon price signal would likely be more challenging. In this case, it might be less profitable to shift to lower carbon activities and individuals would have an incentive to avoid compliance. This increases enforcement costs.

From the perspective of a long-term transition towards a very energy- and carbon-efficient society, reliance on regulation with little use of a carbon price signal has a second drawback. It is difficult to anticipate the nature and focus of future government regulation. Therefore it is difficult for firms to shift their focus towards less carbon-efficient activities and sectors if it is unclear whether the necessary regulation will be in place to create the profitable opportunity for an innovative product or service. In contrast, a robust carbon pricing scheme gives some confidence in the market opportunities represented by lower-carbon products. After all, it is easier to implement regulation to facilitate the use of a profitable technology in the context of a carbon price than to mandate the use of an unprofitable technology in the absence of a carbon price.

Furthermore, a comprehensive set of regulations to encourage carbon- and energy- efficient production and consumption choices seems a rather complex enterprise; after all, energy, and thus carbon, is present in almost all production decisions. Their explicit regulation would likely create a very inflexible economy that does not seem very suitable to incentivise innovation and to explore new technologies, business models and services for a shift to a low-carbon future.

The discussion illustrates the value of a clear emissions trajectory which is reflected in an appropriate carbon price signal. But it similarly points to the value of a clear emission reduction trajectory to commit governments to implementing complementary policies. Without commitment to such a trajectory, a government will struggle to manage the many small regulatory changes that are necessary to facilitate the shift to a low-carbon economy. The similarity to the budget of a government is striking: how would a government be able to prioritise expenditure and make sometimes tough decisions on projects that cannot be supported, if it did not have to balance expenditure and income in the annual budget? Furthermore, an overall emission target is necessary to allow the general public and investors to hold their governments accountable should they fail to act. Thus the emission trajectory provides an important component of a framework to deliver tailored regulation which ensures the adjustment of institutions and market designs for the use of new technologies.

2.1.6 The opportunity for low-carbon economic growth

Current discussions on economic stimulus packages often fail to outline a long-term strategy. If the objective is to encourage firms to invest, they need to see a growing market which would justify expanding production capacity. In the past, biotech and dotcom booms, and subsequent development of markets in China, provided ample opportunity to gain long-term perspectives and expand production and markets. It seems desirable to combine economic stimulus packages with a similar or even more powerful vision that can attract investor interest.

The transition to a low-carbon economy offers ample opportunity for new processes, products, and services, and if policy can paint a credible picture of this vision, then this can create the opportunity and attraction for the desired investment.

Awareness about climate change is increasing in the corporate world, but the level of attention devoted to the impacts and opportunities to act is still insufficient among many decision makers in the corporate world. This limits expectations about ongoing and future policy responses to climate change. Policy makers will therefore have to demonstrate their commitment to climate policy today, in order to capture the attention of these corporate decision makers.

The price of EU ETS allowances provides one effective indicator of market expectations about the stringency of climate policy. Market participants – paying only 15 Euro/t CO_2 – clearly evaluate government climate policy as not very ambitious. The model results of this exercise point to higher prices and the interpretation of the model results suggest that the market price of carbon allowances should be even further above this level. European Parliament and Member State governments must make decisive moves to push up the level of ambition so as to create market opportunities for low-carbon products, services and innovation.

As access to capital for investment is difficult in the current market environment, and the management of many utilities remain more interested in mergers, rather than in using their comfortable balance sheets to accelerate investment in low-carbon options, governments are required to provide direct funding, for example using feed-in tariffs, or regulatory frameworks for infrastructure investment in low-carbon activities.

2.2 Concerns about and responses to asymmetric carbon prices

Author: Susanne Dröge

Regional leadership in climate policy reflects the political reality that the level of ambition in climate policy is determined domestically. Ambitions differ and so do the carbon constraints applied to investors and consumers. Moreover, the responsibilities for reducing carbon emissions should be differentiated between developed and developing countries, with developed countries demonstrating leadership and illustrating how low-carbon growth strategies could work.

Regional leadership also offers the opportunity for economic growth in new sectors, thus contributing to competitive advantages in world markets. The sectors which are of particular relevance in this respect are the residential and commercial building and passenger transport sectors. However, recent discussions in the EU and the US illustrate the political challenges in manufacturing. For this sectors, the major concern is that ambitious climate policy creates incentives to relocate production, and thus diverting instead of reducing emissions. This effect, coined as ‘sectoral’ carbon leakage, could undermine regional ambitions to reduce carbon emissions at home in order to protect the climate globally.

In the manufacturing sectors, emission reductions are expected both from efficiency improvements and from substitution of new products, services and processes. Such changes are difficult to administer, but can be incentivised with a full carbon price. Hence, these are the domains where political discussion of carbon leakage is most prominent.

Figure 2-6 illustrates the ‘dilemma’ that carbon leakage supposedly presents:

- a full carbon price signal can trigger leakage, and therefore relocation of emissions, rather than their reduction;
- avoiding the carbon price signal, e.g. with a free allowance allocation which is to some extent conditional on continued operation (as e.g. part of the EU Directive and even more so with the USA's output-based rebates), removes incentives to shift to low-carbon processes, products and services which are likely to constitute a large share of the opportunities for emissions reductions.

This trade-off is, however, a misleading representation:

- If leakage occurs in a sector, lower-priced imports will replace domestic production, and therefore the carbon price will not be passed through the value chain. Avoiding carbon leakage is thus not only an industrial interest, based on competitiveness concerns, but also an environmental one.
- In many sectors, carbon leakage is not an issue. Therefore these sectors can bear the full, or most of the, carbon cost. This requires a sector-specific analysis which considers product, transport and other characteristics in addition to trade volumes and cost increase.
- In the remaining sectors, emissions leakage can be avoided with tailored solutions, including border adjustment, investment subsidies, or, in a few cases, conditional free allocation.

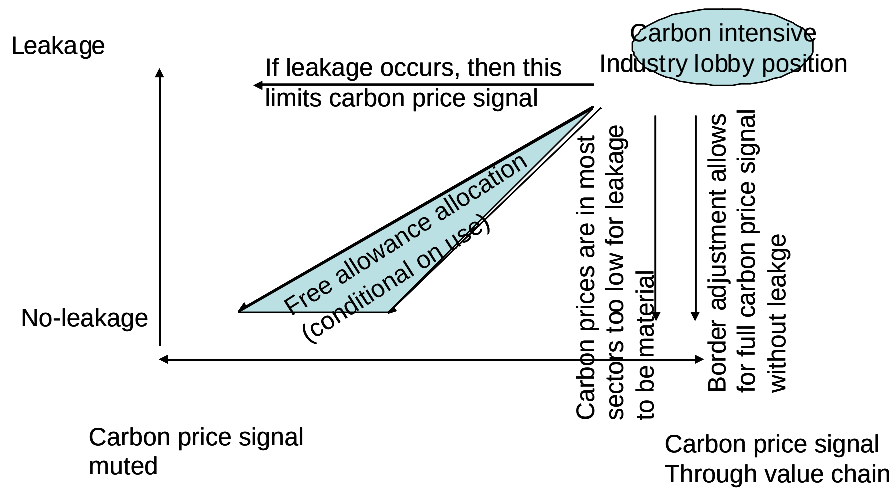

Figure 2-6: The trade-offs involved in different strategies to respond to leakage concerns

Figure 2-7 illustrates the challenges in the political setting. Firstly, given political pressure, leakage will be unlikely, as any policies which would result in leakage are opposed by major political interest groups.

Based on the political setting, there are two potential outcomes to address leakage: (i) free allowance allocation or state aid for investment (left bottom) or (ii) sector-specific assessment with a tailored use of border adjustment in sectors identified as at risk of leakage (right bottom).

Outcome (i) creates overall higher costs for achieving the environmental objective. However, often industry representatives expect higher costs to result in less ambitious targets, and therefore less impact on their constituency in carbon-intensive sectors.

Outcome (ii) is likely to be environmentally more effective and economically cheaper. However, the main beneficiaries are innovative companies which produce low-carbon substitutes for carbon-intensive products, processes or services. Such companies are typically small, with less access to policy processes, and tend to focus their efforts on innovation and operation, rather than on changing government policy.

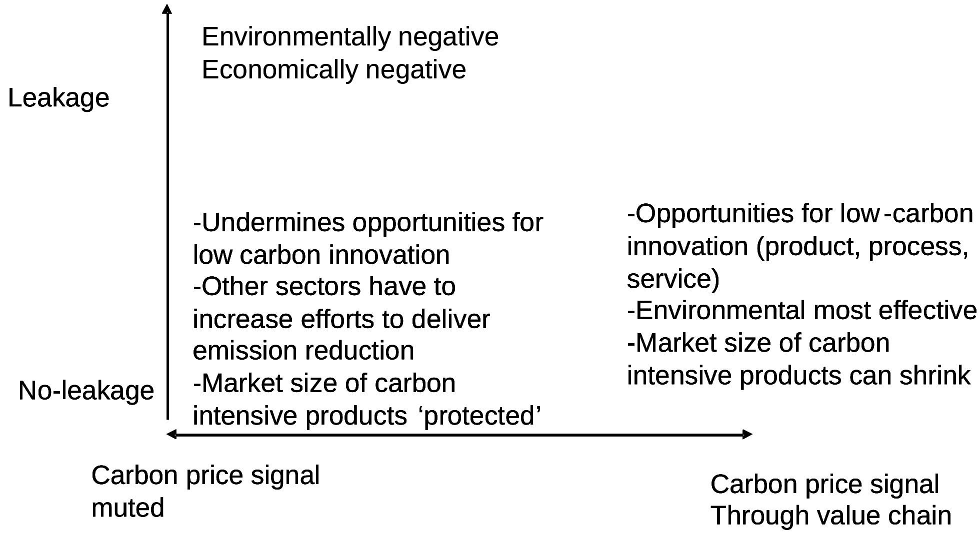

Figure 2-7: The implications of different strategies to respond to concerns about leakage

Two rounds of national allocation plans for the EU ETS and the subsequent design of EU ETS for the period to 2020 have demonstrated how susceptible national governments are to lobbying pressure from heavy industry (Neuhoff et al., 2006a). Yet this helps to preserve traditional industrial structures and prevents future market opportunities for low-carbon products.

An additional challenge is that, with free allowance allocation, much of the profit stream of companies is driven by the value of free allowances. This dominates any business strategy and prompts management to focus on lobbying, even at the expense of improving the core business, technology and products of companies.

The following analysis shows the challenge for investment choices in the context of weak governments. The issue is not 'leakage or no leakage' but rather whether there will be 'a carbon price signal or no carbon price signal'?

2.2.1 Concerns about emission leakage and competitiveness impacts from unilateral higher carbon prices

Concerns about the effects of unilateral carbon pricing on the competitiveness of industry and on the effectiveness of such an approach to global emissions reductions have been under discussion since the Kyoto Protocol established the groups of Annexe I and Non-Annexe I countries.[3] Competitiveness concerns centre on the effect of the carbon price on a firm's profits and market share, and depend on a number of factors. The same holds for the response from industry which would result in a shift of emissions to regions outside the EU

[3] Gerlagh/Kuik 2003: Trade liberalization and carbon leakage. The Energy Journal, 24, 97-120, for an overview of quantification of carbon leakage. See Reinaud, J. (2004): Industrial Competitiveness under the European Union Emissions Trading Scheme. IEA Information Paper, Paris. See e.g. Frondel et al. (2008) for a critical approach focussing on the indirect costs from electricity pricing: Frondel, M.; Schmidt, C.M.; Vance, C. (2008): Emissions Trading: Impact on Electricity Prices and Energy-Intensive Industries, Ruhr Economics Papers No. 81, RWI Essen

ETS territory. From an industrial point of view, a unilateral carbon price is regarded as threatening market share and profits.

If costs must be passed through in order to keep the break-even point of profitable production, then in a fully competitive world, market-shares will go down, as competitors without a carbon cost take over sales. If the current market position allows a company to capture some rents, then the company will have to assess whether to protect these rents and reduce its market share, or to reduce the rents and protect the market share. For a few sectors there might arguably be other locations that would enable higher profits, a relocation of investment is a crucial mid- to long-term factor in strategic decision making.

However, the impact on firms' operational and investment decisions can differ for a number of reasons. First, the impact of carbon costs on the overall cost structure (fixed and variable costs) differs in each sector and sub-sector. Direct carbon costs from emission certificates are determined along the value chain by the production process; thus, costs depend on the input structures and cost components as well as technology. Indirect carbon costs from electricity production have an additional impact on energy-intensive sectors. If electricity is supplied by third parties (energy producers), the cost impact depends on the extent to which energy producers can pass through their carbon costs. Second, pass-through of carbon prices to product prices depends on market structure, i.e. competition in internal and international markets. Again, this can vary throughout the value chain. Trade exposure of the industries with a significant carbon cost impact is a third factor which determines whether industries face competitiveness concerns from carbon pricing. Moreover, pass-through also depends on vertical integration and supplier-customer-interactions, long-term contracting, quality parameters, and other regulatory specifications for industry. This means that, while international competition from producers who are not facing carbon constraints limits cost pass-through, other factors could partly offset this limitation.

The migration of carbon emissions to other regions depends on the actual industry operation and investment strategies that are induced by competitiveness concerns. There are basically three options. First, if industry passes on the carbon cost, the price signal could lead consumers to shift demand to cheaper substitutes, probably imported from regions without carbon pricing. This would ultimately entail market exit by some players. Second, industry substitutes part of the value chain by outsourcing to suppliers from regions without carbon pricing. Third, investment will be made in locations outside the EU ETS. All three options will shift emissions abroad, leading to carbon leakage. These effects, however, do not represent the only channels through which global emissions can be affected. Figure 2-9 shows all three leakage channels.

1. The energy market channel. This is part of CGE models which deal with leakage caused by the Kyoto Protocol. The models assume that reduced energy demand by parts of the world with ambitious climate policy reduces fossil fuel prices, thereby triggering demand increases and emissions in other parts of the world. However, the results are sensitive to the representation of the energy market: e.g. assuming climate policy results in a shift from coal to gas imports, this will increase global gas prices, but might not alter coal prices in the mid term. The net effect on energy demand and mix in other countries is even more difficult to predict.
2. Induced change in industrial operations. This is the focus of competitiveness and sectoral analyses, as described in this section.

3. The technology diffusion channel, which describes positive global effects through carbon price-induced innovation and diffusion of low-carbon technology and policy around the globe.

For the debate of the EU ETS, the second channel, as described above, was at the heart of the debate.

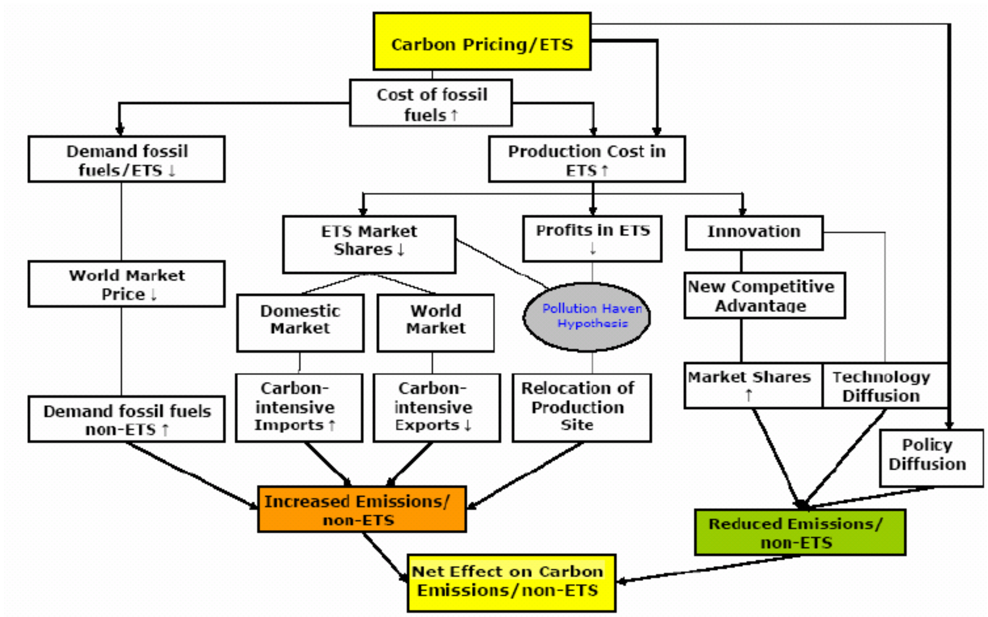

Figure 2-8: Leakage Channels: Energy Markets, Competitiveness, Technology Diffusion. Source: Droege et al (2009)

2.2.2 Cost increases are significant only for a small set of sectors

Analyses of the competitiveness effects on energy-intensive industries under the EU ETS show a limited impact in terms of the actual number of trade-exposed sectors which face a carbon-cost increase (measured as share of gross value added). These industries, such as cement, iron and steel, refineries or fertilisers, have high direct emissions due to combustion and processes, and indirect emissions from electricity input.[4] Due to the limited number of sectors and the low level of value added (homogeneous basic products), their share in overall GDP is limited, as studies of UK and German industries show (1.1% in UK, 2.1% in Germany at a carbon price of €20/t CO_2eq).[5] This estimate of the impact on sectors increases if the underlying carbon price increases.

[4] Hourcarde; J. et al. (2007): Differentiation and dynamics of EU ETS industrial competitiveness impacts. Climate Strategies Report, Climate Strategies 2007; Graichen, V. et al. (2008): Impacts of the EU Emissions Trading Scheme on the industrial competitiveness in Germany. Climate Change 10/08. Umweltbundesamt, Dessau-Roßlau, Germany de Bruyn, S.; Nelissen, D.; Korteland, M.; Davidson, M.; Faber, J.; van de Vreede, G. (2008). Impacts on Competitiveness from EU ETS - An analysis of the Dutch industry. CE Delft, Delft, 2008. www.ce.nl.

[5] Hourcade Demailly, Neuhoff and Sato (2008): *Differentiation and dynamics of EU ETS industrial competitiveness impacts. 2007***.** Data: 2004

Another issue is the extent to which the production of goods which use inputs from energy-intensive sectors is affected by asymmetric carbon pricing. This determines the share of GDP which is affected. However, the further up the value chain, the lower the share of the carbon price in a product and thus the impact on company market share and profits.

2.2.3 The risk of carbon leakage

Since competitiveness studies have identified a small set of sectors for which carbon pricing creates a challenge, the possibility that carbon leakage will become a serious issue for climate policy makers depends also on these few sectors. These sectors are likely to include cement, iron and steel, refinery, aluminium and some basic inorganic chemicals.

As mentioned, in order to calculate the actual carbon leakage potential, an investigation is needed to identify the drivers of carbon leakage, determining operation and investment decisions.

- value at stake,
- trade intensity,
- share of carbon costs in annual fixed and variable costs,
- product differentiation,
- transport costs, other trade barriers,
- strategic responses of firms, expectation of duration of price difference,
- political framework.

Simulations of the potential impact of the EU ETS, using parameters calibrated according to historic production and trade data, indicate that for cement, iron and steel, the risk of leakage can be significant if a long-term price difference of 20€ /tCO_2eq is assumed and no measures to address leakage concerns are assumed. Aluminium producers, in a sector with a high share of indirect carbon costs associated with the production of electricity used for the smelting process, often have long-term contracts with power suppliers. Therefore, in the past, there was only limited concern about leakage risk, but a changing global demand for aluminium, and the future need to renew long-term contracts might alter this situation.[6] The simulation for future leakage under the EU ETS phase III shows that, for cement, aluminium and steel, an average leakage rate of around 10% is likely, if one assumes the “extreme” case of unilateral action and full auctioning of emission permits.[7]

In sum, all investigations from a sectoral, bottom-up modelling perspective, suggest that carbon leakage is only a narrowly defined concern for operational and investment decisions of a few sectors. It may be useful to implement a tailored solution for these sectors, in order to keep them operating within the EU ETS territory and thus preventing emission relocation.

The following table lists insights from different regional studies and the top sectors affected.

[6] Gielen et al 2000, Demailly et al 2006, 2008, Ponssard et al 2008, Reinaud 2008; Reinaud&Quirion (forthcoming), Walker&Quirion (forthcoming).
[7] Monjon and Quirion (2009): Addressing leakage in the EU ETS:results from the CASE II model, Climate Strategies Working Paper, forthcoming

Table 2-1: Sectoral studies on carbon pricing effects

Study	Country	Aggregation level	CO2 price	Indicator of carbon cost impact*			Ranking of sectors along carbon cost impact
				Denominator	Process emissions	Electricity	
Carbon Trust (2004)	UK	2-3 digit SIC	€20/ t CO2	GVA	yes	yes	1. Iron and Steel; 2. Aluminium; 3. Chemicals; 3. Food and tobacco; 4.Cement and construction; 4. Pulp and paper
Morgenstern et al. (2004)	USA	4 digit SIC (USA)	US$ 1/ t	Total cost	no	yes	1. Petroleum refining; 2. Products of petroleum and coal; 3. Lubricating oils and greases; 4. Carbon black; 5. Asphalt paving mixtures and blocks; 6. Lime
Hourcade et al (2007)	UK	4 digit SIC	€ 20/t CO2	GVA	yes	yes	1. Lime; 2. Cement; 3. Basic iron and steel; 4. Refined petroleum; 5. Fertilisers and nitrogen; 6. Aluminium
Houser et al. (2008)	USA	2 digit SIC (USA)	-	Final sales value	yes	no	1. Alkalies and chlorine; 2. Lime; 3. Pulp mills; 4. Primary aluminium; smelters; 5. Nitrogenous fertilisers; 6. Newsprint mills
Graichen et al. (2008)	Germany	4 digit NACE	€ 20/t CO2	GVA	yes	yes	1. Cement; 2. Lime; 3. Fertilisers and nitrogen compounds; 4. Basic iron and steel; 5. Aluminium 6. Paper
de Bruyn et al. (2008)	Netherlands	2-4 digit SIC	€ 20/t CO2	Total cost	yes	yes	1. Cement, calcium, gypsum; 2. Fertiliser; 3. Iron and steel; 4. Aluminium; 5. Inorganic chemicals 6. Other base chemicals
Citi Group Investment Research (2008)	Australia	Company (ASX100)	A$ 20/t CO2	Market Capitalisation	yes	yes	1. Energy Developments (Power) 2. Cement, lime, constr. mat., 3. Steel, 4. Paper, 5. SP AusNet (Power), 6. AGL (Power)
Commission Services (2008)	EU-27	8 digit (partly aggregated) PRODCOM	€ 30/t CO2	Product price	yes	yes	1. Cement clinker; 2. Quick lime; 3. Chlorine; 4. Grey Portland cement; 5. Ammonium nitrate 6. White Portland cement

Indicators of carbon cost impacts can be distinguished according to components included in the numerator and the choice of the denominator. Carbon cost includes direct and indirect costs. Direct costs stem from process emissions; indirect costs stem from a carbon cost mark-up included in the electricity price. These costs can be related to gross value added (GVA), turnover or other indicators of company activity. The maximum value at stake is defined as the sum of potential direct and indirect costs in relation to the GVA of a given industrial sector.

Source: Mohr et al. 2009, Climate Strategies

2.2.4 The merits and side-effects of policy options to address leakage

The European experience illustrates that it is currently difficult to implement full auctioning of allowances to sectors that are potentially at risk of carbon leakage. One reason for this is that there is a lack of adequate data and of a robust analytic framework on which to base political recommendations. This makes it difficult to assure policy makers that there is a limited risk that asymmetric carbon prices might result in relocation of some production, as well as the associated jobs and emissions.

As a result, different policy instruments are under discussion, to address concerns of potential leakage.

There are three *short-term* options to level carbon costs with respect to operation and investment.

1. Border Adjustment, including rebates for exporters from the EU ETS, carbon costs for importers to the EU ETS, based on carbon intensity in production at home and abroad, and implemented through financial tools (tariffs, taxes) or allowances;
2. Free allowances for industries at risk, with allocation conditional on their existence, capacity or recent production volume;
3. Investment support for efficiency improvements in sectors that might be at risk of leakage.

The long-term options include:

4. International agreement on carbon pricing (under UNFCCC)
5. Sectoral agreement on carbon pricing

The more credibly and earlier long-term options are implemented, the less need there will be for short-term fixes. After all, leakage concerns are largely linked to investment and closure choices, and they in turn respond to expectations about future carbon price differentials.

For the choice of the most suitable short-term option at least three criteria must be considered:

First, flexibility in the light of international carbon pricing efforts and negotiations.
Second, effectiveness in addressing operational and/or investment leakage.
Third, keeping up the carbon price signal for the EU ETS territory and beyond.

Border Adjustment

Border Adjustment can be applied with a variety of tools, either on exports or on imports. There are different ideas circulating about border adjustment relating to final products (carbon-content based) and being conditional on a country's overall effort in addressing climate change (deterring free riders). However, the following relates to a rather limited concept of border adjustments, applied multilaterally to level carbon costs for energy-intensive industries that are prone to carbon leakage.

The first decision on this tool from a climate policy point and based on emissions trading is whether it should be applied in money or in allowances. From a WTO law perspective, emissions trading represents a mix between a charge and a regulation. Both categories are dealt with under WTO law, but there is no precedent for carbon trading schemes. Either way, the challenge is to ensure that the implementation is pursued in a way that is compatible with WTO rules and that the application of border adjustment does not undermine the sense of co-operation on climate policy.

The most important aspect to be considered for WTO compatibility is that producers of like products are not discriminated against if they access the market of the country or region vis-à-vis its own producers. A WTO-compliant definition of whether a products is like depends on a product's characteristics, not on manufacturing processes which leave no trace; thus, under WTO rules, any carbon emission abroad is not a relevant basis for border adjustment to level carbon costs up to a national standard. One design option which might satisfy WTO criteria is the definition of a common, multilaterally agreed international standard. If a border adjustment is based, e.g., on the carbon intensity of the best available technology, this will not create discrimination if all trading partners have signed up to the standard or if the importing country assumes that all trade partners fulfil this standard.

A crucial aspect of border adjustment is that, in theory, it should follow actual emissions in production. Then adjustments would work both ways, creating a carbon price which matches the actual processes applied, regardless whether a producer is located within or outside the EU ETS.

Regarding the first element, multilateral understanding, the current situation in global trade negotiations is very sensitive. The Doha Round under the WTO has come to a stalemate mainly because industrialised and developing countries cannot agree on a reduction of tariffs for industrial products. Adding carbon-cost border adjustment to the agenda would contribute to further deterioration of negotiations. Furthermore, application of border adjustment raises concerns about protectionism. Thus, any use of border adjustment will have to be preceded by informal processes to create a common understanding of the purpose, and to find common ground on how to manage this tool.

Free allowance allocation

Handing out allowances for free was the approach European industry preferred for addressing leakage. After all, this approach produced tangible results in the form of valuable transfers to the respective sectors, which representatives of those sectors could demonstrate to their employees and shareholders.

While free allowance allocation can compensate for the cost increase a producer incurs due to carbon pricing, this does not automatically address leakage concerns. After all, an installation might sell freely allocated allowances and use the revenues to finance the relocation of production facilities. Therefore, the free allocation of allowances must be linked to existence, availability or production of the respective installation, in order to be effective in addressing leakage. However, such conditions do distort the carbon-price signal and therefore reduce incentives to reduce CO_2 emissions in the sectors that receive allowances for free, as was demonstrated in analysis of national allocation plans during the first two trading periods of EU ETS (Neuhoff et al., 2006b).

The design of a scheme of free allowance allocation therefore must trade off the effectiveness of the allocation in addressing leakage concerns against the distortion of the carbon price signal.

It has been agreed that for the period post-2012, some form of benchmark would have to be used for free allowance allocation in Europe. This aims to ensure that industry does at least retain the incentive to increase the efficiency of production processes, even if incentives to shift to more efficient fuels, production processes, or lower carbon products and services might be distorted.

Direct compensation

The direct compensation option to address leakage could be added to existing tools in order to ensure that investment and re-investment in low(er)-carbon technology takes place in the EU ETS territory.

If return on investment hinges on carbon costs, and higher returns are expected outside the EU ETS, this can be compensated for with a subsidy for carbon-friendly technology. This is likely to be an effective mechanism for sectors with high capital costs, particularly if they are at a point in their investment cycle where near re-investment in the light of carbon pricing will not be profitable in the EU ETS territory. Thus, direct compensation on a case by case basis could address investment leakage very effectively, if it is made conditional on information disclosure by industry, as well as on continued operation.

Moreover, the indirect carbon costs from electricity cost pass-through could be addressed by this tool, mainly in sectors with a high share of indirect cost such as aluminium. Electricity production as such is not subject to high trade intensity; thus the substitution of power from regions without carbon pricing is not an option for the power consumers.

While case-by-case support for investment will not necessarily undermine the carbon price signal for industry, a generic subsidy to all new investment in a sector can again feed through to lower product prices. Therefore it will be important to find criteria which are closely linked to the level of innovation and carbon intensity of a new production site for the State Aid approval of such subsidies, so as to limit the amount of subsidy, and the distortions it creates, to the largest extent possible.

2.2.5 International co-ordination to avoid negative impacts

All measures to address leakage need to take into account the international progress under the UNFCCC. This may include a globalised carbon market and the levelling of the playing field. Such a strategy must not be obstructed by anti-leakage policies that create lock-ins for inefficient carbon pricing schemes over long periods. Instead, any scheme needs regular revision in the light of international negotiations.

International co-ordination should also be applied to the introduction of carbon pricing as such. In order to create a global market for carbon allowances, the design of national schemes, their underlying cap, the allocation method, the tools to address competitiveness and leakage all determine how fungible the certificates would be for trading under the foreign schemes. For border adjustment application, as mentioned, no unilateral approach should be taken; moreover, and international co-operation which simultaneously facilitates the focussed application and limits the broader proliferation of border adjustment is a key element.

The more trading schemes emerge and involve major trade partners with carbon-intensive sectors around the globe, the more detrimental free allocation will be. Free allocation is a subsidy to domestic firms and undermines environmental effectiveness. Direct subsidy of investment is likewise an undesirable tool, and hence either option should be applied for a short a period and on as small a scale as possible.

2.2.6 Conclusion

Carbon price differentials can cause a problem for the effectiveness of a unilateral emissions trading scheme such as the EU ETS if industry starts relocating its production or if there is substitution of domestic production through imports. Price differentials will remain for the coming decades, and competitiveness impacts for energy-intensive industries do matter for the actual emission reductions on a territory.

There is no one single tool to address the potential migration of emissions to non-EU ETS regions. Given that competitiveness studies show a low number of sectors that are at risk of leakage, sectors must be screened according to their specific cost impact (direct or indirect, variable or fixed cost) and then a tailored solution should be applied.

The most effective tool is cost adjustment at the border, since this addresses exactly the driver of the problem: trade flows. Any tool needs to be revised in the light of international efforts to put a constraint on carbon emissions. Border adjustments are regarded as green protectionism by most developing countries and thus will not work without careful design of the tool within a multilateral approach and limited to specific sectors. Also, generous free allocation or direct subsidies could be seen as unfair by competing regions. Co-ordinated action on tackling leakage would be the better choice, and would avoid allegation of unfair trade practices.

3 Low-carbon technology policy

Key messages:

Governments must make commitments to deploy new technologies; the private sector is too dependent on policy and too risk averse to lead the necessary long-term transition

A combination of tailored policies and carbon pricing is required to create initial opportunities/cash flow and a long-term business case

A portfolio of technologies is required to meet decarbonisation targets

Member States should create consistent, comprehensive and verifiable National Action Plans to outline their strategy to deliver their EU renewable target and support the necessary portfolio of renewable technologies (not only low-cost options)

A tailored carbon capture and sequestration (CCS) policy is necessary, to ensure the different components of the supply chain are delivered by appropriate agents, with effective risk and reward sharing

3.1 The complementary roles of technology specific support and carbon pricing

Author: Karsten Neuhoff

Recommendations for climate policy action typically combine a trio of: carbon pricing, regulatory measures and technology policy (cf. e.g. Stern, 2006). We briefly discuss the different rationales presented to motivate government technology policy and then use the structure of the innovation chain to explore the different components of technology policy.

Economists often focus their analysis on whether markets or regulatory instruments are the most suitable policy instruments for delivering a certain outcome. It has become customary to first assess whether the market could be expected to deliver the welfare-optimal outcome, and only pursue direct government intervention if market failures are identified which would prevent the market from delivering an efficient outcome. This analysis then also offers the opportunity to target such interventions at the identified market failures. This clear structure offers the opportunity for a transparent and targeted approach, and thus can reduce regulatory uncertainty.

Following this tradition, many market failures have been assessed that might contribute to under-investment in innovation in market-only environments. These include: technology spill-over that prevents firms from appropriating benefits from R&D and learning investment, constrained access to capital for small innovative firms, and more broadly, challenges of coordinating companies where this is necessary for transition. In addition, many of the negative externalities on energy import dependency, environment and climate are still not fully reflected in market prices, and thus under-price the benefits of new innovation.

The types of market failure can vary across different technologies and sectors, and therefore the response must also vary across technologies and sectors. While tailored deployment schemes might be the focus of some technologies, more weight might be devoted to targeted R&D expenditure, or an increased incentive through higher carbon prices to address market failures in other sectors.

However, the discussion in recent years has been evolving beyond this initial approach of analysing market failures. As it becomes increasingly clear that our societies will require a core set of new energy-efficient and low-carbon technologies in order to achieve the 2°C stabilisation scenarios (cf. Luderer et al., 2009), a new question has emerged: will the current policy environment ensure the development and deployment of a sufficiently large subset of core technologies?

Many economists argue that the market will deliver sufficient investment in innovative low-carbon technologies if market failures are addressed. There has not been enough time for empirical evidence to appear, but ongoing discussions about investment in power stations are insightful. After 15 years of liberalisation of many power markets, there is still no consensus as to whether power markets create the appropriate incentives for investments in power generation that secure electricity supply. If economists are not even confident that this investment will be pursued, it seems risky for policy makers to fully rely on the market to deliver the technologies which will deliver emission reductions.

Hence a new set of questions is emerging as to how governments can ensure that a large enough set of technologies will be pursued and developed. Section 3.2 and 3.2 explore such policies using the examples of CCS and renewables.

3.1.1 Technology pipeline & learning by doing

The innovation process can be divided into several key development stages (Grubb, 2004). The first stage, research and development, is typically followed by a gradual move into the second phase of demonstration projects or prototypes. The subsequent commercialisation phase provides market experience to tailor the product to consumer demand, explore smart ways of manufacturing the product and accumulating experience and production scale to reduce costs. This can ultimately generate the right conditions for widespread deployment and diffusion of the product.

Movement along the innovation chain is determined by synergies between the different stages of the process. Experience during demonstration, commercialisation and diffusion can guide research and development. In turn, this can trigger new demonstration and subsequent commercialization of the improved technology, turning the process into a repeated cycle.

3.1.2 Innovation Policies: Research, Development and Demonstration

Research, development and demonstration lie at the heart of the innovation process. Public and private R&D spending represents the critical driver of experimental and emerging technologies. It bridges the divide between a concept or prototype and the demonstration of production processes or technology components. Applied R&D, especially in the private sector, is driven by market demand, or potential market demand, and thus focusses more heavily on development. Public R&D activity tends to focus on more basic and applied research, although strong overlaps and synergies exist between these dimensions. Collaboration between the public and private sectors is important for sharing experience and driving innovation (Ockwell et al., 2006).

According to the OECD, member countries account for 85 % of total R&D spending globally. This amounts to over US$800 billion annually (OECD, 2007). Of this, the public sector of IEA members spend around $11 billion on public sector energy technology R&D, whilst the private sector accounts for another estimated $40-60 billion annually (IEA, 2008a). Estimates suggest that overall power sector R&D spending has declined in both the public and private sectors since its peak around 1980 (Figure 3-9)[8].

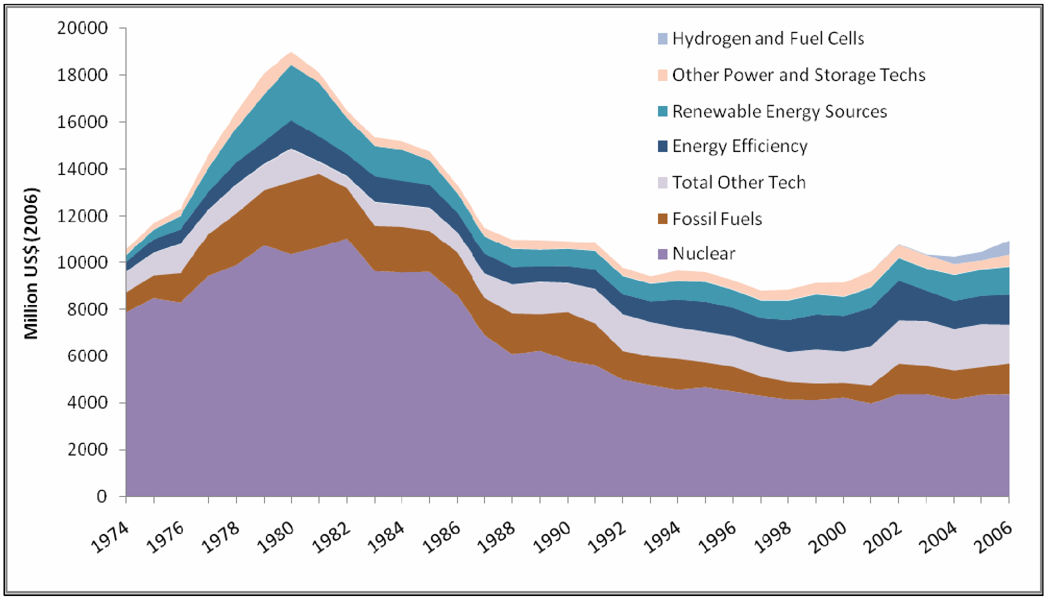

Figure 3-9: Technology Share of IEA Public Expenditure on RD&D

Historically, research and development in the energy sector has been lower than that in product-driven industries (Grubb et al., 2008). In the private sector, R&D can be limited because it is very difficult for firms to fully appropriate their investments in R&D (Margolis and Kammen, 1999). Technology spill-over in the energy sector is large (Neuhoff, 2007), making it harder for private sector agents to recover the full benefits of innovation and breakthrough. This, along with the failure of markets to fully internalise environmental externalities, undermines the incentive to achieve an optimal level of innovation. Various policy instruments create support for innovation in the energy sector:

Publicly-funded research and development programs

In many OECD economies, the public sector has directly funded research into novel renewable technologies. In the USA, such funding has been channelled through the Department of Energy (US DOE, 2005), while in the UK, such direct funding for R&D has been provided by the Research Councils. The USA, in particular, have seen a significant

[8] It should be noted that public R&D expenditures are only a partial proxy for overall energy R&D activity. For several emerging low-carbon technologies such as Solar PV and biomass, many of the important technological steps have occurred outside the energy sector and beyond conventional energy research funding- e.g. in the biotech and electronics industries.

increase in funding for clean coal technologies, which might explain the sharp increase in the technology's patent activity after 2005.

Direct capital grants and subsidies

Innovation in the Danish wind sector was encouraged in two ways. The first stemmed from direct grants for R&D programs. The second stemmed from the increase in market demand due to a subsidy for the installation of turbines, in the order of 30 % of the investment (Karnøe, 1989). These solutions were directed at both ends of the innovation chain, supporting R&D and providing the enabling environment for commercial application. Similarly, innovation in the Japanese PV sector was supported by capital grants and direct investment aid. In 2007, Japan had the second largest country share of production (23.8 %), with Germany holding the largest, at 35 % (IEA, 2008b).

Technology demonstration

Technology demonstration is used to establish whether emerging technologies are capable of working on a commercial scale (Garibaldi, 2007). It requires sustained investment and improved risk/reward ratios (Foxon et al., 2004). Public financial support can assist with the demonstration phase. A key factor in the development of clean coal technologies in the US was government-supported demonstration plants, which led to private sector participation in the development of next-generation concepts (Bañales-López & Norberg-Bohm, 2002).

3.1.3 Policies for Technology Use: Commercialization and Diffusion

The transition between demonstration and the commercialisation and diffusion of a technology is the point at which many technologies fail to survive (Grubb, 2004). Many technologies in their infancy are not yet cost-competitive and are therefore not widely adopted by industry. This is particularly pertinent in the energy sector, where a majority of technologies have benefited from many years of governmental support and incremental learning. Various enabling activities can be used to bridge the gap between demonstration and commercialisation:

Growing initial markets

An important factor that determines whether firms will invest in production capacity and pursue ongoing product improvement is their confidence in a growing market for the product (Bañales-López & Norberg-Bohm, 2002). Costs of newly commercialised technologies can decline as a result of the incremental process of learning and innovation arising from an increase in production, installation and economies of scale.

For some technologies, the removal of energy subsidies from conventional (fossil and nuclear) technologies is sufficient to create a commercially viable environment; others might require the full internalisation of environmental externalities to be cost competitive (Garibaldi, 2007). In particular, the homogeneous nature of energy provision limits the role of natural niche markets for new technologies, and points to the importance of government policies for the strategic deployment of a technology during its commercialisation phase. This could involve tenders, feed-in schemes or direct subsidies for low-carbon generation sources. For example, in South Africa, the diffusion of PV panels in rural settlements was accelerated following the introduction of a subsidy for the cost of installation. Such support mechanisms can ensure the increased scale of a market for a new technology (Nemet, 2008).

In addition, loan guarantees or soft loans can facilitate access to capital markets for earlier stage technologies which, by their very nature, do not have the track record required by banks to underwrite loans. With loan guarantees, some debt finance can be included for initial projects, and equity freed up for accelerated investment in innovation. Obviously, sufficient of the project risk must remain with technology companies so as to ensure sufficient focus on quality of the projects.

A growing market is not only important for a narrowly defined technology, but also for the broader industry included in the supply chain. It allows for the transition from small operations to mass production of the technology, including training and development of other facilities, such as after-sales service, insurance, maintenance and quality checks. Thus, the building of local markets and local absorptive capacity facilitates subsequent technology use. Figure 3-10 illustrates this using the increasing deployment levels, for example of renewable energy technologies across all model runs.

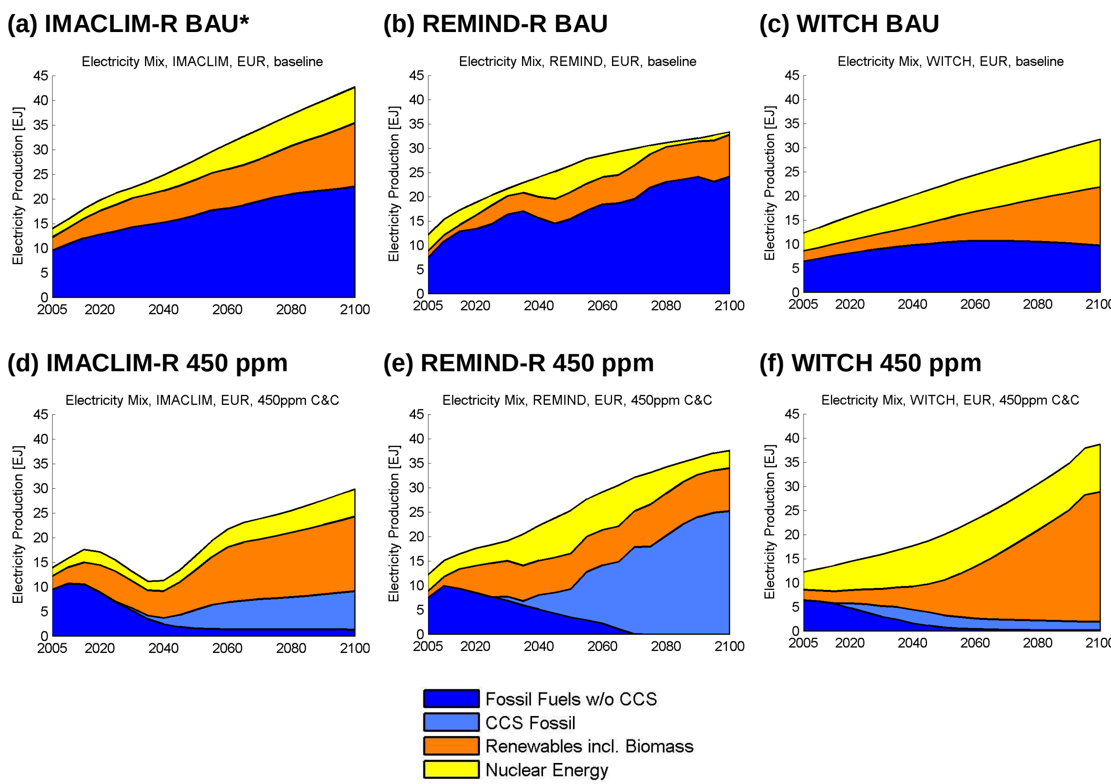

Figure 3-10: Electricity mix for the European power sector (IMACLIM-R and WITCH) as well as power and heat for REMIND-R; for further explanation see Luderer et al. (2009).

Non-financial support during commercialisation

The risks associated with new technologies could be mitigated through the establishment of stringent quality standards and regulations. This can build confidence in local technologies (Siikavirta, 2006). In 1978, a test station for wind turbines was established at the Risø Centre in Denmark. This not only provided the resources to demonstrate technologies but also allowed quality standards to be set for the technologies. All Danish designs had to undergo a demonstration phase at the Risø Centre before they could be authorised for commercial use (Karnøe, 1989), ensuring that sub-optimal technologies did not proceed to market.

Improving the regulatory environment

Diffusion of a technology at the domestic level is generally driven by the development goals of a country. More specifically, technology choices will be made relating to the local needs of the country. Lu et al. (2007) suggest that the success of China's clean coal technology industry was driven by the introduction of technical policies with tangible goals and penalties. Environmental policies enhanced the incentives created by technology policies by implementing stringent emissions standards (Lu et al., 2007). In 1997, the Chinese government distributed their 9th Five-Year Plan on Clean Coal and Development, valid until the year 2010. It is believed that this document became the driving force in the CCT industry (Yu & Yu, 2001). Discussions on the appropriate policy framework to support CCS are moving in a similar direction. Increased emphasis is being placed on setting mandatory standards for capture-ready plants or setting future plant emissions standards that are so high that CCS must be employed.

Non-market barriers for implementing new energy-generating technologies, such as difficulties in accessing the electricity grid and power market, may also need to be removed.

The role of carbon prices

Technology-specific support schemes are typically justified as a means for delivering learning benefits, overcoming initial barriers for diffusion, compensating for environmental or security of supply externalities that are not fully reflected in market prices, or to facilitate investment by new entrants with new technologies against the vested interest of incumbent companies. However, all of these motivations tend to have a temporary component. To reassure strategic, long-term investors, it is therefore important that new low-carbon technologies eventually become cost competitive, both through their cost reductions and through cost-reflective pricing for carbon-intensive incumbent technologies. Carbon pricing reduces the time it takes for new technologies to become cost-competitive, and increases the profitability of the new technologies thereafter. Thus carbon pricing plays an important role in incentivising investment in new technologies.

Carbon pricing versus technology-specific support schemes

Across sectors, countries, and technologies, the relative importance of carbon pricing and technology-specific support programs for innovation varies. This is a function of the need for technology-specific support and the ability of governments to provide technology-specific support.

The need for technology-specific support increases when technology spill-over is large. This can be the case because ideas are visible, easily replicated or reverse engineered, and are difficult to patent. In contrast, with rapid technological progress (as in IT), innovation is often faster than such spill-over; in areas such as fashion, brand reputation plays a strong role. In sectors such as the chemical industry, innovation might be entangled in a complex production process and thus be better 'protected.'

The ability of government to provide technology-specific support again depends on several factors. The starting point is ability to clearly define the objective. The failure to clearly define such objectives might explain why few people ask for government leadership in technology-specific support for the fashion industry, whereas more such voices are present in the generation of electric power. It is furthermore important that governments have the institutional capacity to manage the provision of technology-specific support. Historic experience of large research projects, for example in the nuclear area, illustrate the risk of capture – where the linkages between the supported enterprises and research tanks and the funding government agencies eventually become so closely tied that independent evaluation is difficult. In contrast, renewable energy technologies are sourced in competitive markets, with clearly defined market interfaces which allow for more transparent monitoring of quality and cost evolution and support volumes provided to the industry. The following two sections discuss two such technology-specific support schemes, using the example of renewable energy technologies and carbon capture and storage.

For technologies where the objective of technology development is simple to specify and governments are in a better position to manage technology-specific support, as with renewable energy sources, technology-specific support schemes can play the leading role. However, they must be complemented by carbon prices to create industry confidence in the long-term viability of renewable technologies.

In contrast, for technologies which have more complex characteristics, such as energy efficiency improvements in chemical production processes, it is more difficult for governments to define the objective of the improved process. After all, improvement is not being sought from energy efficiency in an individual production step, but in the production of the final product; therefore the interactions between production steps must also be considered. In such cases, a strong carbon price signal is likely to be more effective in incentivising private sector activity. Unfortunately, the EU ETS has, on the contrary, weakened the carbon pricing signal with free allowance allocation to industrial sectors, and thus undermined incentives for innovation in the very sectors where these incentives, delivered through the carbon price, are most important.

This analysis points to the importance of high and unmitigated carbon prices, particularly for industrial sectors so as to enhance incentives for low-carbon innovation.

Creating options

Technology innovation is by its very nature an uncertain process. It is unclear how well individual technologies will perform. The model runs therefore illustrated the benefit of developing a portfolio of new technologies, for example for power generation. Thus, even with one or two technologies not performing, the cost of a decarbonisation strategy remains manageable.

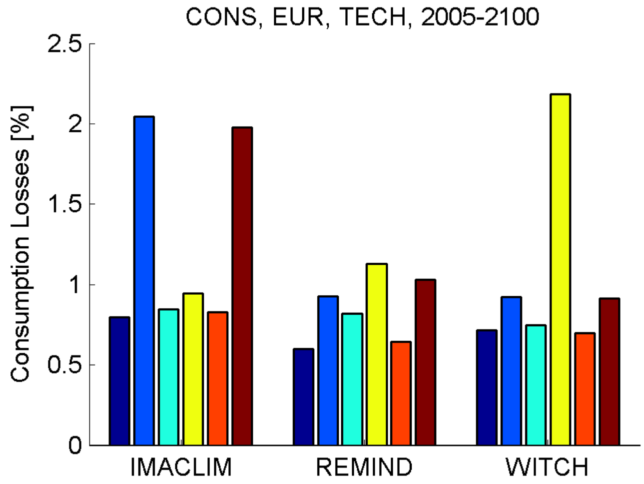

Figure 3-11: Total mitigation cost with individual low-carbon technologies not available

Investment in a portfolio of technologies can therefore be interpreted as an insurance policy, to ensure availability of (low-carbon) enough energy technologies even if some fail to mature to the desired extent. Will rational private sector actors invest in the insurance policy and therefore ensure the availability of the necessary technologies? Probably not. When the insurance is required, the additional technology option increases the volume of available low-carbon energy, reduces its costs, and thus benefits overall society. Yet this is a positive externality for which the investor is not rewarded.

The problem is furthermore aggravated because of the way in which actors deal with risk. For a firm to invest into a new technology which serves as an option to be used to ensure against low-carbon energy scarcity is very risky. The option will only be used in the unlikely event that other technologies are not available. Individuals who invest their career or investors who put their money into activities that only have a low probability of payout expect an extra large reward. However, it is unclear whether these investors will be appropriately rewarded in quasi-regulated energy markets, particular if the value of their contribution becomes apparent only in a state of desperation because of a lack of low-carbon energy.

This points to two potential failures of the market that might prevent private sector provision of the necessary portfolio of low-carbon technologies. Public policy must respond by providing technology-specific support towards development of a range of technologies. This is in order to ensure a sufficiently large portfolio of low-carbon technologies is developed, demonstrated, and manufactured at sufficient scale to evaluate the value of the technology to society.

3.1.4 Creating Synergies between Stages in the Innovation Chain

Johnson and Jacobsson (2002) suggest that in the early stages of research and development, technology uncertainty is high and firms must be encouraged to explore a variety of options. Alic et al. (2003) support this view and recommend that funds be made available for a wide range of programmes to encourage competition and support diversity. This highlights the need to maximise the benefits of feedback loops and synergies between stages in the innovation chain, to ensure that strategic innovation and technology deployment takes place.

Encouraging a variety of innovation streams

It is important to avoid taking a myopic view of innovation support. For example, R&D-led attempts in Germany, the USA and other countries in the early 1980s, which focused exclusively on building multi-megawatt wind turbines, failed on the grounds of both engineering and cost (Norberg-Bohm, 2000; Bergek and Jacobsson, 2003). However, private and subsequently public initiatives in Denmark supported a wide range of R&D, in small to large wind turbines (Jensen, 2004). Through applied experience, the turbine manufacturers learned how to address design challenges, and turbine sizes gradually increased (Grubb and Vigotti, 1997). Between 1993 and 2001, strategic investment in R&D for wind energy cost Denmark an estimated US$1.4 billion in subsidies. Meanwhile, annual revenues of Danish wind companies were $2.7 billion by 2001, the vast majority of which came from their dominant position in export markets (Carbon Trust, 2003).

Building Confidence in future market opportunities

By outlining industry requirements and capacity targets, governments can assist in guaranteeing a future market for technology. In Denmark, the adoption of an energy plan in 1981, which outlined a target of 10 % wind contribution by 2000, created private sector confidence in the future of the industry (Karnøe, 1989).

Policies that remove ‘old technology’ energy subsidies and internalise carbon costs create future market opportunities for low-carbon technologies which succeed in the commercialisation phase. These policies are therefore important for innovation and investment decisions in low-carbon technologies, even at times where technologies still require additional support from government-sponsored commercialisation programmes.

In summary, the experience from national technology policy illustrates that public support for Research, Development and Deployment (RD&D) is necessary to assist innovation in the energy industry. Commercialisation of a technology is encouraged through the generation of market demand or by guaranteeing the existence of a future market. Strategic deployment programmes, improving the regulatory environment and ensuring that quality standards are adopted accelerate the use of new technologies. Foxon et al. (2005) highlight the crucial role of a stable and consistent policy framework to support this iterative process. Effective technology policy can accelerate the development of the necessary technology portfolio for a low-carbon transition. Diffusion into other countries typically is far faster than initial innovation. Thus technology policy in Europe can also contribute to decarbonisation in other regions. For investors in the supply chain, combined efforts in technology policy across regions offer the advantage of global market opportunities which offer further protection against policy uncertainty.

3.2 Crucial Elements for Incentivising Cost-Efficient and Secure Storage of CO_2

Authors: Hermann Held and Ottmar Edenhofer

3.2.1 The economic potential of CCS

Global Scale

Carbon Capture and Storage (CCS) represents a major potential mitigation option, both in technical and economic terms, according to the latest IPCC report and WGIII, as well as our own analyses. Worldwide, cumulative storage of ~2000 $GtCO_2$ appears to be economically optimal (Edenhofer et al., 2006), given a 450ppm target (i.e. of never transgressing that concentration limit in the future). While this target is regarded as ambitious in the worldwide policy arena, significant voices from climate science, in conjunction with parts of the environmental movement, claim that even more stringent greenhouse gas (GHG) stabilisation targets should be implemented, such as a 350ppm CO_2 target (cf. e.g. Hansen et al., to be subm.). While we do not necessarily agree with all of their inferences, based on a simplified extrapolation of data from the last glacial period, an independent set of arguments does, in fact, support the conclusion that a 350ppm target may be highly desirable. Here we mention just two of them: (i) according to a semi-subjective analysis in Lenton et al. (2008), a 2°C increase of global mean temperature implies that the Greenland ice sheet will ultimately be lost over the next 100 to 1,000 years, leading to an additional rise of global sea level of seven metres. (ii) In order to have a greater than 50% to near 100% chance of achieving the 2°C target, stabilisation levels of 350 rather than 450 ppm are required (e.g. IPCC (2007), citing work by M. Meinshausen).

For these reasons, we investigated two specific roles of CCS when tightening the stabilisation target from the EU’s 2°C target to the additional requirement that from 2150 onwards, 350 ppm shall not be transgressed (abbreviated as ‘350 ppm target below’).

(1) The cumulative amount of CO_2 to be stored when optimising economic welfare.

(2) The option value of CCS (i.e., the welfare gain when adding CCS to the mitigation option folder, which includes renewables, nuclear, and energy efficiency measures).

We considered both aspects for different values of linear annual leakage rates of CO_2 (from the ‘gold standard’ of 0.01 % per year to 1 % per year).

For (1), we found the effects of the leakage rate to dominate the effects of the stabilisation target (Haller et al., in prep.). For 0.01 %, 0.1 % and 1 % per year, we found 300-400 $GtCO_2$, 50-100 $GtCO_2$ and 0 $GtCO_2$ of geological storage to be economically optimal. These numbers also appeared robust (within 30 % probability) with respect to uncertainties of the global carbon cycle.

In contrast, for (2), the stabilisation target kicks in as a crucial parameter; the 2 °C target comes with consumption losses of 1-1.5 %, 1-1.5 % and 1-2 % (i.e., the more leakage, the higher the consumption losses), while the 350 ppm target results in losses of 2.5-3 %, 5-7 %

and a situation in which the target cannot be met (at whatever costs), respectively. This means that, for a very tight target, the gold standard of 0.01 % leakage per year (representing an efficiently-operating CCS system) is ultimately necessary on a global scale. Put in another way, the results suggest that targeting 350 ppm may imply considerable side effects, either in terms of economic loss or potential side effects from massive deployment of CCS.

Therefore, the leakage rate appears as a crucial system parameter (Edenhofer et al., 2005) and for that reason we would like to repeat an observation we have made more than once: that there are vastly differing claims about how possible and practicable it is to infer and control the leakage rate. According to our preliminary assessment, the future will witness heated debate about what a ‘proven maximum leakage rate’ shall be, and about what observational scheme shall define it. This in turn would also have consequences for defining the most suitable incentive schemes for secure storage. While energy suppliers and geologists regard <0.01 %/year as an absolute minimum quality standard value for good practice, geo-scientists seem unable to agree on whether such numbers can be established by observational networks. In fact, **direct verification** of even 0.1…1 %/year may represent a scientific challenge if the location of leakage is a priori unknown. We believe investment in observational infrastructure is worthy of being subject to economic optimisation, as it is such infrastructure which would determine a 'provable' maximum leakage rate (Held, Gerbig et al., to be resubmitted.).

European Scale

Utilising the REMIND-R, model, we also estimated the option value of CCS for Europe. Given the fact that CCS is subject to criticism by several stakeholders, and that Europe holds above-average potential for renewables, we derived the extra costs of the 2°C target when excluding the CCS option (those extra costs we call ‘option value’ in that context). We find that the extra costs stay below 1 % of GDP when CCS is eliminated from the option folder in Europe only (and also when fixing ‘nuclear’ to BAU; however, if CCS is eliminated globally, CCS-attributed GDP loss in Europe is ~2 % of GDP). These numbers seem to suggest that Europe could abstain from CCS if it wanted to do so, providing that the rest of the world eased pressure on a future worldwide CO_2 cap by using CCS.

However, we must point out that those numbers given in the paragraph above implicitly assume that further investment in renewables would bring about the anticipated cost reduction, and that we went for the 2°C target only, not yet for the additional target of 350ppm. Therefore, as an economic precaution, it would still appear rational for Europe to develop CCS to the demonstration stage, to have the option for massive deployment of CCS from 2020 onwards in case there is the political will at that stage. We will elaborate on a potential incentive structure for the demo phase in the last section.

3.2.2 EU Directive on the geological storage of CO_2

The aim of the Directive on the geological storage of carbon dioxide (2009/31/EC) is to establish a legal framework for the environmental safe geological storage of carbon dioxide. It regulates the selection of storage sites, exploration and storage permits, operation, closure and post-closure obligations as well as third party access to transport network and storage sites.

Only such storages sites with no significant risk of leakage and for the environment and health shall be selected. Storage sites in operation have to be monitored to ensure that leakage will be discovered early. Additional inspections by government authorities at least yearly are regulated. If any leakage occurs, countermeasures are mandatory and under certain circumstances the storage permit can be cancelled. Operators have to ensure that costs for the whole operation period are covered before the storage permit is issued.

The operator remains responsible after the closure of the storage site for maintenance, monitoring, controlling, reporting and measures to prevent leakage. The Member State can take the responsibility for the site 20 years after the site is closed and sealed. This is only possible if the site is considered to be safe. Nevertheless, the operator has to cover for costs that may occur after the Member State has taken the responsibility for the site. This is addressed by a dedicated fund.

The Directive should help to incentivize Member States and private sector investments to ensure the construction and operation by 2015 of up to 12 CCS demonstration plants. The construction of these plants should be supported by national governments providing 300 million allowances from the EU ETS (New Entrants Reserve)[9]. This way support for CCS demonstration plants depends critically on the allowance price level. When new power plants (>300 MW) should be constructed, the operator has to check if CCS is a technical and economic option. If this is the case, sufficient space has to be kept free for retrofitting carbon capture.

3.2.3 CCS Bonds as Incentives for secure storage

While the Directive sets desirable boundary conditions it leaves considerable space for decision in terms of operationalisation. We anticipate a series of conceptual difficulties when it comes to in-practice public acceptance and safe operation of market-scale CCS. In the following we would like to describe one possible new instrument, suggested by ourselves to the community, to address those difficulties.

The bond schemes described in the following assume that CCS has already penetrated the market and is characterised by massive deployment. In Germany, that could mean the storage of ~20 $GtCO_2$ in saline aquifers (May et al., 2005). When extrapolating numbers from Germany's Federal Environmental Agency (UBA, 2006), that volume would imply an area doped with CO_2 equalling that of a whole German state. This implies an environmental management challenge of unprecedented scale, either calling for a massive up-scaling of personnel in environmental authorities, or for an additional instrument of risk management.

For the latter, we suggest that for each unit of CO_2 to be stored, the operator must buy a **CCS bond** (Edenhofer et al., 2005; Held et al., 2006), to be held by the state authority and handed back after 30 years or so, with high interest if leakage has been proven below a certain limit. If the operator can convince the capital market of safe operation, the operator can sell the option on that bond early on. Such schemes have attracted favourable interest from the four largest German parliamentary parties on the federal level, although potential future operators

9 Not only CCS will be supported, also demonstration projects of innovative renewable energy technology will profit from this.

remain sceptical. Major questions that remain unanswered by our bond papers (Edenhofer et al., 2005; Held et al., 2006) were:

1. How is the bond price to be estimated?
2. Why should a company consider CCS, if it has to buy a bond in addition to the extra costs of CCS?
3. Why do we need a bond scheme, if we must in any case purchase CO_2 emission certificates in the case of leakage?
4. If the interest rate on the bond is high enough to attract purchasers, would successful deployment of CCS not ruin the state in the long run?

In this document, we outline a first set of answers to these four crucial questions, also detailed in Held & Edenhofer (2009)[10].

To answer the first question, the bond price must be high enough to over-compensate short-term gains from 'bad practice', i.e. from not monitoring enough. The rather weak constraints on the bond price must be detailed in the future. These investments are minor compared to total CCS costs, hence addressing the second question.

The third question leads to the central reason for a bond scheme. In fact, if the company had an investment horizon similar to society as a whole, i.e. the same rate of pure time preference, our analysis shows (Held & Edenhofer, 2009) that uncertainty on leakage rates across competing storing sites does not raise the need for extra instruments (in addition to the carbon price to be paid for leaking CO_2), if only the climate damages were considered.

We regard the carbon price as a potentially insufficient instrument to incentivize the selection of the best geological formations, for two reasons. First, the carbon price does not cover local environmental damage. Instead, a CCS fund is frequently proposed to rectify damages. However, if no feedback loops – from quality of practice to insurance premiums – are considered, such a scheme creates a moral hazard.

Second, and more fundamentally, private sector investment behaviour is most likely characterised by somewhat larger discounting of the future than that which is calculated by capital markets or society as a whole. Hence it can be doubted that the carbon price alone would impose enough of an incentive for investing in measurement campaigns that would allow companies to choose the best geological formations. In-depth analysis shows that governments could enforce best practice via a combination of high interest rates on CCS bonds, coupled with an extra fee for leakage (Held & Edenhofer, 2009). This would neutralise the issue raised by our third question above. However, such a scheme does not appear to be very practical, first because those parameters strongly depend on peculiarities of observational network costs vs. inter-temporal gains from energy production, second, because of the issue raised by our fourth question – the potential for an unacceptably high financial burden on the state if uptake of the bond is overly successful at too high an interest rate. These problems are elegantly bypassed the bond schemes that have been suggested in Edenhofer et al. (2005) and Held et al. (2006). The very fact that the option (either on the

[10] H. Held, O. Edenhofer, *CCS-Bonds as a superior instrument to incentivize secure carbon sequestration*. Energy Procedia, 4559-4566, 1 (1) (2009).

bond or a fresh emission certificate) can be traded within the capital market early on replaces a company's high discount rate with a much lower discount rate more aligned with societal perspectives and capital markets. (Held & Edenhofer, 2009). The bond system can also address the local damage issue in the same instance, without creating a moral hazard akin to that represented by the CCS damage fund. Finally the bond system would again neutralise the issues foreseen by our fourth question, because the capital market does not need such a high interest rate to find the bond attractive.

Future work is needed to elaborate on imperfections in the capital markets and potential insurance schemes accordingly. The bond scheme addresses the issue of storage security in view of potential short-term orientation of companies. However, the short-term vs. long-term investment horizon question may be virulent way beyond CCS, and may have to be evaluated for other investments (such as into renewables) in view of a future high carbon price as well: is the expectation of a high price far into the future reason enough for companies to adequately (from society's point of view) invest today into low-carbon technologies? If not, further instruments in addition to a cap and trade system might be necessary.

3.2.4 Bidding Scheme for European CCS Demo Projects

Any of the schemes outlined in the previous section assumes a minimum degree of knowledge in the markets about the properties of CO_2 storage system properties, to allow for the setting of a bond price. Such knowledge might be propagated through a series of CCS demonstration projects that must be designed to be as informative as possible.

Although some strains of research indicate that Europe's over-proportionate potential for renewable energy sources may economically suggest an under-proportionate share of CCS within Europe, we still regard it as necessary to implement up to 12 CCS demonstration projects before ~2015. Large-scale deployment of CCS is in the same situation as massive deployment of renewable energy sources, in that both represent a not entirely proven technology. Hence, Europe should develop a portfolio of options until 2020 as a hedging strategy against unexpected technological or economical failures in any of these technologies. For that very reason, we fully support the *Proposal for a directive of the European Parliament and of the Council on the geological storage of carbon dioxide*, which calls for the European Commission's support for the development of up to 12 large-scale demonstration projects by 2015, as a rational hedging strategy.

However, in order to extract as much information out of those demo projects as possible, we suggest a bidding scheme for those projects, using the following check-list of criteria:

1. Any project must demonstrate the whole technological chain, from capture to transport to storage. The bidding scheme must ensure that any of the three competing capture technologies and any of the major geological alternatives of underground formations are covered.
2. A life-cycle assessment of the whole technological chain is to be outlined, including energy and material consumption, as well as chemical emissions (in particular absorbers) into the environment at the combustion and capture stage.
3. An observational scheme for the determination of potential leakage must be outlined. Our analyses show that leakage below 0.01 %/year is preferable. However, even 20-60 % of maximum deployment of CCS would still be economically optimal (given the 2° target) if a rate of <0.1 %/year could be proven by an observational system. CCS becomes useless if leakage of up to 1%/year cannot be excluded. While energy suppliers and

geologists regard <0.01 %/year as an absolute minimum quality standard value for good practice, it seems to be a matter for disagreement among geo-scientists as to whether such numbers can be established by observational networks; in fact, direct verification of even 0.1 to 1 %/year may represent a scientific challenge (as already mentioned above). Therefore, we propose that the bidding scheme should take into account the extent to which the proclaimed detection limit is supposed to be based on a dense network of real observations as against/in combination with indirect inferences from geodynamical modelling exercises (which are often only sparsely validated).

4. As the demo projects are still in the early stages of exploration, there may be surprises, regardless of present-day-knowledge of best practice. Hence, locations should also be ranked according to potential for above-surface damage in case of leakage. As ecological impact chains are often poorly researched, we recommend using the operationalisation criteria suggested by the German advisory council on global environmental issues, co-developed by PIK (WBGU, 1998), designed for such situations. It proposes that preference should be given to projects which do not have potential local side effects (the 'ubiquity-criterion'). For that reason, we suggest that projects should be avoided that pump CO_2 under or into the vicinity of lakes: while a 'standard' CO_2 leak would affect only a ‘meter by meter’ area, acidification of a well-mixed lake could have an impact larger by many orders of magnitude, and potentially also poisoning public acceptance of CCS. Along the same lines, geological systems should be avoided which could allow displaced subsurface brine water to leak through known geological faults into rivers or lakes. Environmental institutions should be involved in putting together a recommended list of suitable areas.

In addition, we regard it as highly desirable to test the applicability of the market-based instruments recommended earlier in the chapter for incentivising the choice of the securest instruments (bond schemes) as early as the demo phase, which would allow a bond price to be derived. Accordingly, the following criteria (5)-(7) should be added:

5. The percentage of CO_2 the operator is willing to run under a bond scheme.
6. The bond price the operator is willing to pay.
7. The interest rate the operator is expecting for the bond.

As a final remark on CCS, one has to state that the global storage capacity has been estimated and reported in IPCC’s Special Report on CCS (2005). However the capacity is subject to large uncertainty for which reason we cannot exclude the possibility that secure formations may become a scarce resource in the future (Edenhofer et al., 2009a). If so, they should become subject to market instruments (to be allocated optimally) as well. This holds in particular if society goes for a 2°C target or even stricter targets that may require negative emissions by end of this century, hence inevitably some sort of extraction of CO_2 (i.e. by using biomass) plus storage. Then the scarce resource of storage sites should not primarily be used up from fossil fuel-operated plants in advance on market-phase scale.

3.3 Renewable energies

Authors: Jan Strohschein and Mario Ragwitz

In mid-December 2008, the European Parliament adopted the text of the Directive on the Promotion of the Use of Energy from Renewable Sources (EU Commission, 2009b). It is recognized as an important milestone for the promotion of renewable energies in the electricity, heating and cooling, and the transport sector.

The new Directive establishes an overall binding target of a 20 % share of renewable energies in the Community's gross final energy consumption to be achieved by each Member State, as well as binding individual national targets by 2020, in line with the overall EU target of 20 %.

Besides the new Directive, EU Member States have implemented a wide variety of supporting policies and measures for the use of renewable energies. These were often based on former Directives, such as the Directive on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market (2001/77/EC) and the Directive on the Promotion of the Use of Biofuels or Other Renewable Fuels for Transport (2003/30/EC). Previously, no EU legislation comprehensively covered heating and cooling in the residential and commercial building sector,[11] a gap which has since been addressed by the new Directive.

3.3.1 Renewables in the RECIPE-scenarios

With respect to the EU's renewable energy target, model results show that the EU target is met for the electricity sector in both the 450ppm Contraction and Convergence (C&C) and the 410ppm C&C scenarios (cf. Luderer et al., 2009). Nevertheless, the three models (IMACLIM-R, REMIND-R and WITCH) show different shares for renewables due to their different assumptions and design. It is obvious that the smaller the uncertainty, the easier it would be for investors to bring technologies to market. To minimise this uncertainty, the EU target of a 20 % renewables share by 2020 is very helpful; meanwhile, a clear policy framework, which supports a portfolio of renewable technologies, is necessary.

3.3.2 Barriers for the development of renewables

Within the RECIPE-project, a whole set of barriers was identified for the development of the use of renewable energies in the electricity sector. For detailed analysis, we refer to the sector studies Bodirsky et al. (2009).

The barriers can be grouped into the following categories:

Cost factors (e.g. high investment costs for photovoltaic),

Legal and administrative barriers (e.g. lengthy administrative procedures),

[11] In the Building Directive (2002/91/EC), the use of renewable energies for heating & cooling is regulated for buildings with a total useful floor area over 1,000 m^2.

Techno-economic factors (e.g. variability and intermittency, requiring back-up sources, lack of resource (or already exhausted) potentials in some locations; rising steel and silicon costs),

Political factors (e.g. changing support schemes),

Social acceptability factors (e.g. public opposition to hydropower installations, wind turbines and large solar parks),

Other factors (e.g. environmental protection issues (wind turbines: birds; offshore wind: marine mammals; hydropower: fish and riverbanks).

In recent years, these types of barriers for the use of renewable energies in different sectors have been analysed by European researchers. For example, administrative barriers were analysed in the K4RES-H[12] project for the heating and cooling sector. Administrative barriers and grid issues in the electricity sector were addressed in the projects OPTRES,[13] PROGRESS[14] and FUTURES-E[15]. OPTRES additionally analysed social and financial barriers.

3.3.3 Purpose of the EU Directive

While promotion schemes for renewables have, on different levels, quite a long tradition in EU Member States, the European Parliament set a new framework for the promotion of renewables by adopting the text of the Directive on the Promotion of the Use of Energy from Renewable Sources (EU Commission, 2009b).

The new Directive establishes an overall binding target of a 20 % share of renewable energies in the Community's gross final energy consumption and a 10 % share of energy from renewable sources within transport energy consumption by 2020, to be achieved by each Member State, as well as binding individual national targets by 2020, in line with the overall EU target of 20 %.

Regulation at the European level can help to strengthen existing national policies and to reveal the remaining gaps in Member States, especially concerning sectoral coverage. Via national promotion schemes, the European 20 % target helps to induce and support growing markets. It requires Member States to put policies in place to deliver the 20% target along a suggested trajectory, and thus fosters learning–by-doing and technology development, which leads to decreasing prices and security for producers and investors.

To meet the 20 % target, it is necessary to cover all sectors – electricity, heating and cooling, and transport – and make use of a whole set of technologies. For the electricity sector, these are generation technologies powered by wind (on- and off-shore), hydro (run-of-river, reservoir, tidal, wave, sea current), solar (photovoltaic, concentrated solar power), biomass (power plants, CHP), biogas (CHP, engines) and geothermal (deep) installations. In the heating and cooling sector, solar (solar thermal), biomass (heating systems, CHP) and

[12] See www.erec.org/projects/finalised-projects/k4-res-h.html for details.

[13] See www.optres.fhg.de for details.

[14] See www.res-progress.eu for details.

[15] See www.futures-e.or for details.

geothermal (near surface, heat pumps) are applied. First generation biofuels are used in the transport sector. Next generation biofuels are expected to enter the market in the future.

The Directive provides incentives for national governments to pursue complementary policies in order to meet the agreed targets, and national renewable energy action plans should ensure the closing of gaps in the national policy mix. Investments triggered by support schemes for renewables will contribute to a green stimulus[16] and reduce overall costs, as shown by Luderer et al. (2009).

3.3.4 Renewable targets in the EU

National targets

All EU Member States must contribute to reaching the overall target of a share of 20 % for energy from renewable sources in the final consumption of energy. A wide variety of policies and measures have been implemented in Member States. Table 3-1 gives an overview of implemented policies and measures in the three sectors – power, heating and cooling, and transport – addressed by the EU Directive. It also includes the status quo of renewable shares (as of 2005) and national targets for the year 2020.

The promotion of renewable energies has had positive effects on the development of industries and businesses. Due to the strong promotion of wind and photovoltaics, new companies have emerged and created new jobs. Through the ongoing promotion of green electricity and also the strengthening of promotion of renewables in the heating and cooling sector, this development seems set to continue. In particular, the extension of solar heating will support local installers.

On the way to achieve their national targets, countries will face individual costs and benefits when deploying renewable energy technologies. On the national level, benefits include: better economic competitiveness, additional employment, increasing supply security and the reduction of local air pollution. Costs and benefits on the international level will also occur. On the international level, benefits include: mitigation of CO_2 emissions, industrial development and decreasing power prices. Because of the transnational advantages of renewables deployment, it would be appropriate to some extent to share the costs. Ragwitz et al. (2007) suggested separation of national and international benefits, and allocation of national costs according to the level of national benefits. The remaining costs should be shared equally across countries.

[16] For a more in-depth discussion on a green stimulus see Edenhofer and Stern (2009), where the issue is described in more detail.

	2005	Target for 2020	Distance to target	Electricity					Heating and Cooling			Transport	
				Feed-in / bonus system	Certificate system, quotas	Investment grants and soft loans, subsidies	Tender	Tax re-ductions / exemptions	Investment grants and soft loans	Obligation	Tax re-ductions / exemptions	Bio fuel quota	Tax re-ductions / exeptions
Austria	23,3 %	34 %	31 %	x					x				x
Belgium	2,2 %	13 %	83 %		x	x			x				x
Bulgaria	9,4 %	16 %	41 %	x		x			x				x
Cyprus	2,9 %	13 %	78 %	x		x			x				x
Czech Republic	6,1 %	13 %	53 %	x		x						x	
Denmark	17,0 %	30 %	43 %	x		x	x					x	x
Estonia	18,0 %	25 %	28 %	x						x			x
Finland	28,5 %	38 %	25 %	x				x	x		x	x	x
France	10,3 %	23 %	55 %	x			x		x		x	x	
Germany	5,8 %	18 %	68 %	x		x			x	x		x	x
Greece	6,9 %	18 %	62 %	x		x		x	x				x
Hungary	4,3 %	13 %	67 %	x									x
Ireland	3,1 %	16 %	81 %	x					x				x
Italy	5,2 %	17 %	69 %	x	x					(x)			x
Latvia	34,9 %	42 %	17 %	x									x
Lithuania	15,0 %	23 %	35 %	x					x				x
Luxembourg	0,9 %	11 %	92 %	x		x			x				x
Malta	0,0 %	10 %	100 %	x		x							
Netherlands	2,4 %	14 %	83 %	x				x	x			x	x
Poland	7,2 %	15 %	52 %		x			x	x			x	x
Portugal	20,5 %	31 %	34 %	x		x		x	x	x		x	x
Romania	17,8 %	24 %	26 %		x				x			x	
Slovak Republic	6,7 %	14 %	52 %	x		x		x	x			x	
Slovenia	16,0 %	25 %	36 %	x		x			x				x
Spain	8,7 %	20 %	57 %	x		x			x	x			x
Sweden	39,8 %	49 %	19 %		x				x		x	x	x
United Kingdom	1,3 %	15 %	91 %		x	x		x	x			x	x

Table 3-1: Shares of energy from renewable sources in final consumption of energy in EU27 (for reasons of readability of the table, some specific policies are not included). Source: EU Commission (2008); own calculations

National action plans and compliance

The Directive demands renewable energy action plans from each Member State by June 2010 to ensure that the EU target will be met. These plans will include national targets for the shares of energy from renewable sources in transport, electricity, and heating and cooling in 2020. The national action plans will also elaborate on policies and measures which assure achievement of the set targets. Special attention is to be paid to biomass. Member States can develop new renewable policies and enhance existing policies within the framework of these action plans.

To ensure plan compliance, Member States must follow an individual trajectory until 2020, the definitions of which are included in the Directive. Member States which do not meet their trajectory will have to adjust their national action plans to include adequate measures to equal or exceed the trajectories.

3.3.5 Evaluation

Empirical analysis

Feed-in tariffs play a major role for the promotion of electricity generated from renewable resources (Table 3-1). Quota systems based on tradable green certificates have been implemented in six Member States. In addition, investment grants and soft loans have been implemented by many Member States to foster “green electricity”. Investment loans and grants are the main policy in the heating and cooling sector to date. Nevertheless, the promotion of renewable energy in the heating and cooling sector is at an early stage and is nearly stagnant. The new Directive should help to strengthen the promotion of renewable energies in the heat sector, as it calls on Member States to ‘implement minimum levels of energy from renewable sources in new developments and in existing buildings which are subject to major renovation in their building regulation and codes’. The Directive also describes a system for statistical transfers of specified amounts of energy from renewable sources to be transferred from one Member State to another. The Directive also addresses on joint projects relating to the production of energy from renewable electricity, heating and cooling. Whereas there is a European level target for the share of biofuels in electricity generation, for the transport sector renewable energies are mainly supported by various tax reductions and exemptions on the national level. Nevertheless, some Member States have also implemented bio-fuel quotas in their legislation.

While support schemes for the generation of electricity from renewable energy sources are well developed, and both feed-in and certificate-based systems are being successfully applied in Member States, the heating and cooling sector is not robustly covered under current schemes. Support is mainly realised by investment loans and grants but is not strong enough to drive successful development in the case of green electricity. This is likely to change in the future because the new Directive forces Member States to stipulate the 'use of minimum levels of energy from renewable sources in new buildings and in existing buildings that are subject to major renovation'. Some countries have already implemented national legislation to strongly support heating systems based on renewable energies. In Germany, for example, the Renewable Energies Heat Act (EEWärmeG) includes an obligation for the use of renewables for heating purposes in newly erected buildings.

Current discussions about the use of biofuels mainly focus on the transport sector. The EU has set a target for a renewables (including biofuels) share of 5,75 % in fuels in the transport sector in 2010; for 2020, the target is 10 %.

Efficiency and effectiveness

While it is generally agreed, that a portfolio of different renewable energy technologies is needed to achieve low stabilisation, there is lively debate about support schemes for the use of renewables, and their efficiency and effectiveness.

Ragwitz et al. (2007) have analysed the efficiency and effectiveness of support schemes for the use of renewables in the electricity sector, using both a historical and a model-based approach. The historical analysis showed that technology-specific support schemes, such as feed-in tariffs, have successfully triggered substantial capacity expansion. For such schemes, specific conditions must be met. For example, it is necessary for the feed-in tariff rate to be stepped and to decrease over time. Technology-neutral schemes, such as quota and certificate-based systems, can be cost-effective in the short run but are likely to be more expensive in the long run, because they exclude the emergence over time of novel techniques. However, in most of the existing quota systems, also the short-term efficiency was low due to large investment risks associated with uncertainty about future certificate prices.

The IEA (2008c) has also analysed the efficiency and effectiveness of different policies, and concluded that policy frameworks which combine different technology-specific support schemes as a function of the technological maturity are the way to go. The three stages of market development – development, niche markets, mass-market – should be covered by individual support schemes. For the first stage (development, such as second generation biofuels) capital cost incentives, tax credits, rebates and other seem to be most suitable. The second stage (niche markets, such as PV) could be addressed by price (FIT) or quantity based instruments (tenders). The third stage (mass market, such as hydro and soon onshore wind) could be supported or incentivised by certificate systems and market demand.

As previously stated, it is important for investors to find predictable and transparent support schemes for renewables in markets. Only if the support schemes are reliable will the intended development occur.

3.3.6 Beyond 2020 Implementation

Achieving the 20 % renewables target in 2020 is the first step when looking at future development of renewable energies. Beyond 2020, even larger shares of renewables in the energy mix are needed to achieve long-term mitigation targets and tackle climate change. However, this is not only a question of tackling climate change but also of diversifying the energy mix with respect to supply security.

To allow for an ongoing growth of the share of renewables in the long term, it is crucial to support and develop a broad portfolio of renewable energy technologies today. For instance, REMIND-R-results show that the share of PV will steadily grow in the global energy mix after 2030 in the 450 ppm and – to a much larger extent – in the 410 ppm scenario, even though overall energy demand also keeps rising. Other still-immature technologies, such as concentrating solar power (CSP), offshore wind and others, are expected to be additional important contributors to the mid- and long-term renewables portfolio.

3.3.7 Conclusions

Model results from RECIPE show that increasing shares of renewable energies will increase their shares in the European energy mix. The use of renewables will continue to be one of the most important mitigation options for greenhouse gas emissions. The EU Directive will strengthen this development.

Support schemes for renewable energies in the electricity sector have been very successful in the past. EU Member States rely on both feed-in tariffs and quota systems. Technology-specific feed-in systems have proven to be very effective at prompting the deployment of substantial shares of renewable technologies in the energy mix. They are also cost efficient in the long run. In the past, the heating and cooling sector was covered by investment loans and grants, but these instruments were not powerful enough to assure a substantial increase of renewables in this sector. The new EU Directive on the promotion of the use of energy from renewable sources requests the definition of minimum levels of renewables in new and refurbished buildings. In the transport sector, the increasing use of biomass, with its implications for land use issues and biodiversity, is again under discussion.

4 Engaging with developing countries

Prospects for future linking are important, but should not delay initial action

It takes time to establish credible institutions and a credible carbon pricing setup (like credible monetary policy), which are necessary before linking

Future linking can offer opportunity for a global carbon price, positive political momentum, and shared vision.

Limit the role of CDM post-2012

Domestic policies in developing countries and a full carbon price are central to low-carbon development. CDM delivers no policies, and subsidises individual projects, instead of internalising the carbon price to create incentives for actors along the value chain.

The CDM creates uncertainty about emission reductions required in Europe: this delays action and undermines opportunity for leadership

Create mechanisms and resources to support developing countries in low-carbon development

Adoption and diffusion of low-carbon technologies requires a conducive environment. They can only be created by domestic policies driven by domestic stakeholders

Developing countries need to develop low-carbon development strategies which show the necessary level of ambition. These allow the identification of national appropriate mitigation actions (NAMAs)

International framework needs mechanisms and tools to increase scale, scope, and speed of implementation of NAMAs (bilateral/multilateral)

Developed countries must commit public resources, e.g. auction revenue or tax on international aviation/shipping, to make these mechanisms relevant on the necessary scale

4.1 Project based co-operation - the future of the Clean Development Mechanism

Author: Axel Michaelowa

4.1.1 The performance of the CDM to date

The Clean Development Mechanism (CDM) is a project-based offset mechanism which allows industrialised countries to acquire emissions reduction credits generated through projects in developing countries. It has the double aim of generating low-cost emissions reductions and promoting sustainable development in the countries hosting projects. Due to the need to avoid "paper credits", the CDM is subject to a novel form of regulatory governance by a UN-based Executive Board (EB) which is supported by independent auditors (Designated Operational Entities: DOEs). The DOEs validate project documentation with regard to conformity with the CDM rules and verify emission reductions achieved by CDM projects. Once Certified Emissions Reductions (CERs) have been issued by the EB, they can be used by industrialised countries as compliance tools for the emissions commitments defined in the Kyoto Protocol. While the essential elements of this structure were introduced by the Marrakech Accords in late 2001, it has only been fully operational for a little over five years.

The CDM has been surprisingly successful compared to the pessimistic forecasts of economists and policy analysts in the late 1990s (cf. e.g. Bohm, 1999). Given the large surplus of assigned amount units in the countries in transition (the so-called "hot air"), it was expected that there would be simple government-to-government transactions to cover compliance deficits in the industrialised countries. Such transactions could always be performed at a price lower than that of a CDM project and thus crowd out CDM. There was also a widespread belief that nobody would invest in developing countries due to their problematic investment climate. The bureaucracy required to assess the CDM projects and to prevent the issuance of fictitious credits would lead to prohibitive transaction costs. As all the actors involved in CDM had an incentive to overestimate emissions reductions, the environmental integrity of the Kyoto Protocol would be undermined. And finally, developing countries would not participate as they would want to keep cheap emission reduction potential ("low-hanging fruit") until such time as they were due to take up their commitments.

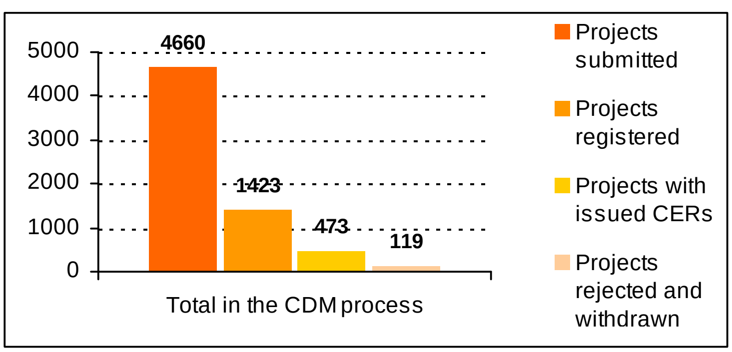

Figure 4-12: Number of CDM projects at different stages. **Source: URC (2009)**

Most of these dire predictions were proven wrong. Mistrust of “hot air” sales by industrialised country policymakers and institutional chaos in the countries with the highest volume of “hot air” have hindered significant transactions. Although direct investment from industrialised countries in CDM projects was rare (cf. Lütken and Michaelowa, 2008), entrepreneurs in developing countries were quick to seize the opportunity and develop “unilateral” CDM projects to generate CERs like an export commodity. By the end of February 2009, 36 % of projects had no industrialised country participant.[17] While everybody in the CDM market complains about the slow pace of the CDM bureaucracy and its high costs, transaction costs seem to be a limited hindrance. Even though earlier analyses (Michaelowa and Jotzo, 2005) had predicted that projects generating less than 20,000 CERs per year would not be viable due to transaction costs, 22 % of projects in the CDM pipeline have an annual forecast of less than 20,000 CERs.

In less than five years, the CDM has mobilised thousands of projects.[18] However, the attrition of projects throughout the project cycle is significant (

Figure 4-12).

The CDM saw a “gold rush” period between late 2005 and late 2008. During this period, on average more than hundred CDM project design documents (PDDs) started the validation process every month. Since the record submission of 200 projects in October 2008, a clear downward trend has started to emerge.

The huge inflows have strained the regulatory system. Delays have considerably increased. Figure 4-13 shows several key delays:

- It is currently impossible to get registration of a project in less than nine months.
- Even 18 months after submission of the PDD, less than half of the submitted projects have achieved registration. A non-negligible share of projects has not achieved registration even after 3.5 years.
- Only two years after submission of the PDD is the first CER issuance achieved.

[17] This underestimates the true number of unilateral projects, as many projects were unilaterally in the beginning but have now sold CERs after their issuance and thus are now listed as bilateral. If one only looks at projects that have not yet been registered, the share of unilateral projects is 44%.

[18] All data in this section are per end of February 2009.

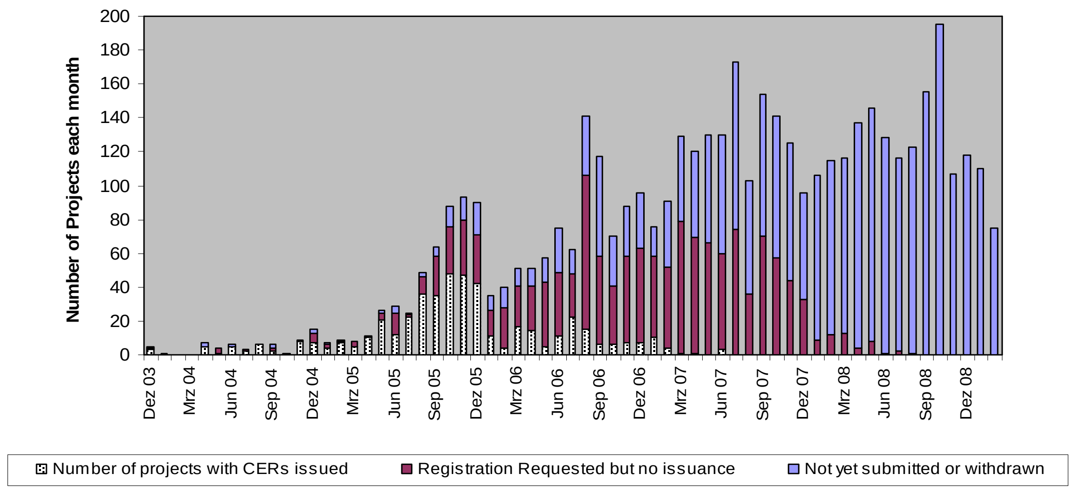

Figure 4-13: Inflow of projects into the validation pipeline. Source: URC (2009)

Despite the length of time projects spend in the CDM process, the quality of project documentation has not improved substantially. The capacity of validators has been insufficient to process the large numbers of validations. Moreover, validation reports have frequently been of low quality, while dubious arguments regarding project additionality have been accepted. Therefore, the share of projects being scrutinised by the EB has risen from less than 10 % to more than half of the submissions, and over 10 % are now rejected (Figure 4-14). During this period, the EB introduced two new layers of scrutiny beyond validation / verification.

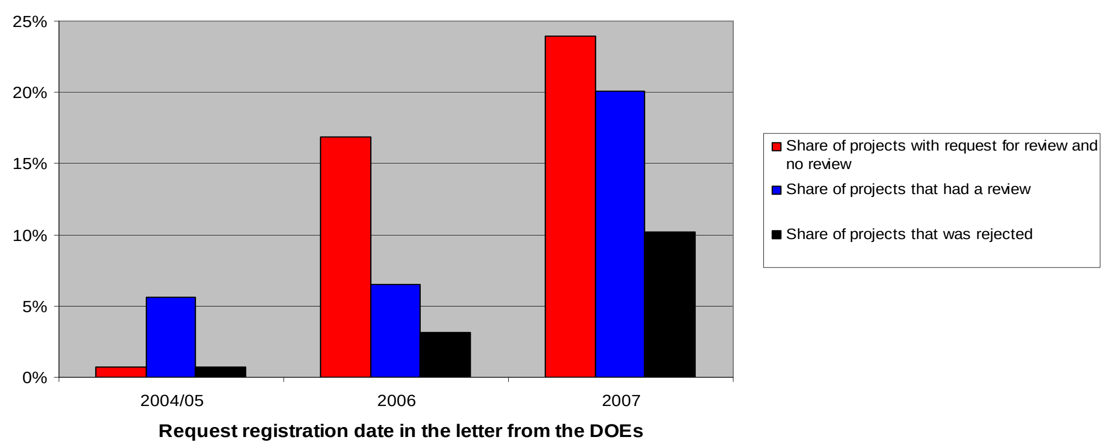

Figure 4-14: Shares of projects scrutinized by the EB. Source: URC (2009)

The CER volumes to be generated before the end of the commitment period in 2012, at different steps of the CDM project cycle, are shown in Figure 4-15.

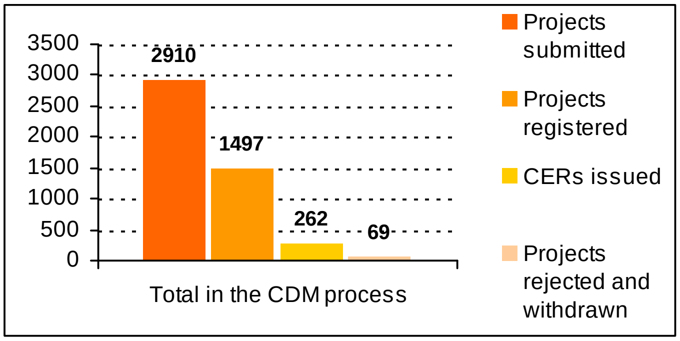

Figure 4-15: CER volumes (million, vintages including 2012). Source: URC (2009)

Current average performance of the CDM, compared to the estimate of CER volumes when the project was submitted for registration, stands at 99.1 %. This figure seems to indicate a very good performance. However, it hides a wide variation between project types with regard to their performance (Figure 4-16). Only three out of 12 project types have over-performed. As these categories are much larger than average in terms of CERs issued, they compensate for the low performance of other project types.

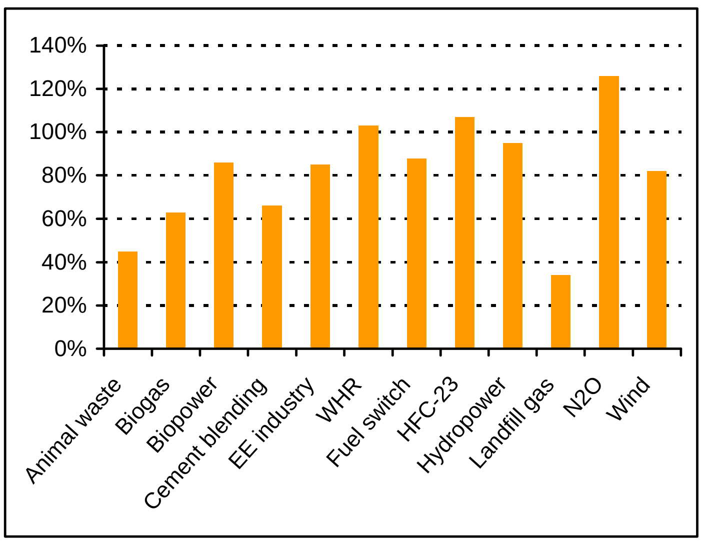

Figure 4-16: Project-type specific performance (%). Note: Only project types with at least five projects that have achieved issuance are included. WHR= Waste heat recovery. Source: URC (2009)

While 76 countries host CDM projects, the bulk of projects is concentrated in three countries: China, India and Brazil (Figure 4-17). This dominance reflects these countries' share in world GDP (a point first raised by Cosbey et al., 2005).

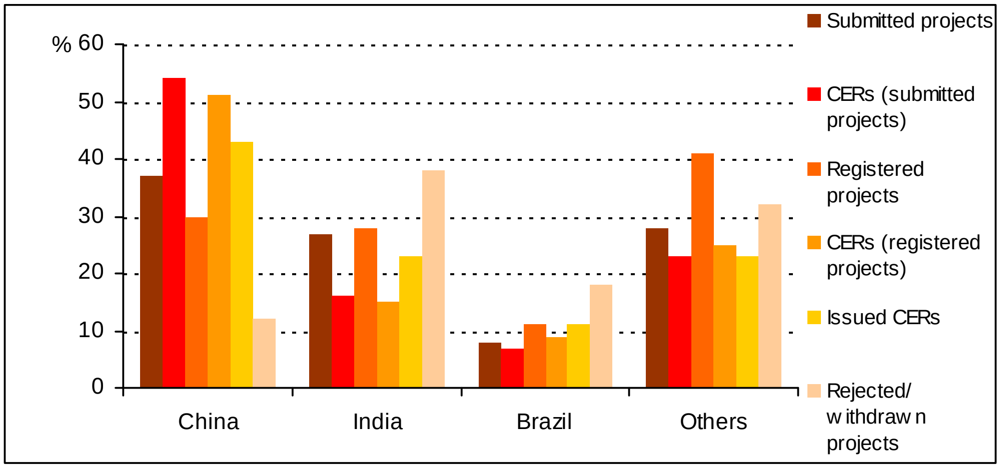

Figure 4-17: Country shares in the CDM (%). Source: URC (2009)

China accounts for one third to half of the CDM, depending on the parameter. It has significantly larger projects than those of other countries, mainly in the industrial gas sector. India covers a fourth to a fifth, with a significantly higher share of rejected projects. Brazil covers about a tenth, with no great variation according to parameter.

Africa, particularly its sub-Saharan part, has so far been largely sidelined by the CDM (Figure 4-18). The African share does not exceed 3.5 % –similar to the share of Africa in world GDP – in any of the CDM parameters. Most of this 3.5% is attributable to projects in South Africa, Egypt and Morocco. Sub-Saharan Africa accounts for 1.5 % at best, and this is only due to two large gas flaring reduction projects in Nigeria. No CER has so far been issued for any project in Sub-Saharan Africa.

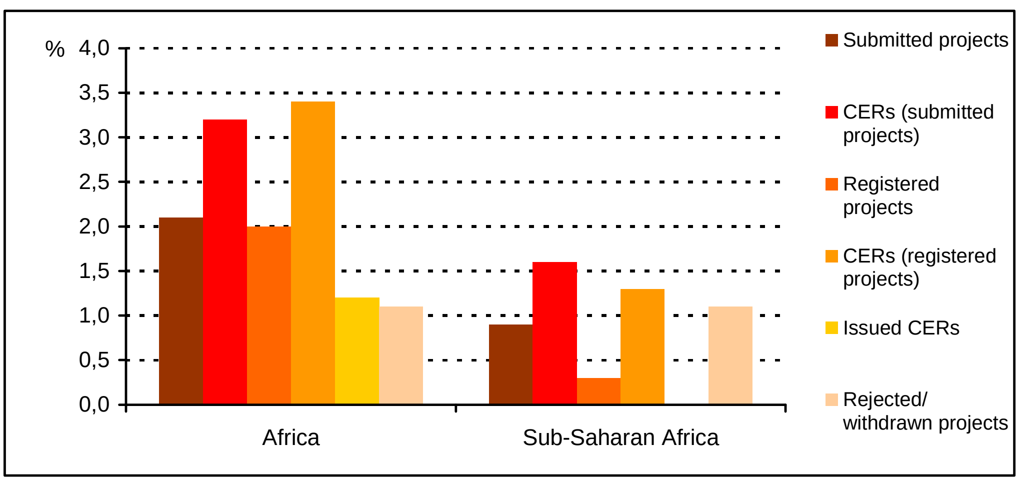

Figure 4-18: African shares in the CDM (%). Source: URC (2009)

By early 2009, over €9 billion had been committed by a wide variety of CER buyers. While the first phase of the CDM was dominated by the World Bank, which set up the Prototype Carbon Fund in 2000 and acquired CERs at an arbitrarily set price of US$3, the introduction of the EU ETS in 2005 and the possibility of using an unlimited amount of CERs within the EU ETS until 2008 led to a rapid diversification of buyers. The unexpected increase in the price of the EU allowances (EUAs) that reached a peak of €30 in early 2006 also led to an increase of the price of CERs, which from late 2004 was essentially pegged to the EUA price. Once it became clear that the EU ETS would not repeat the structural problem of an allowance surplus, banks and hedge funds started to pour capital into the CDM market. By early 2009, the distribution of acquisition programs appeared as shown in Table 4-2. The economic crisis has led to the first dissolution of programs to the tune of €500 million.

Type	Volume (million €)	Number of programs
Multilateral banks	**2150**	**4**
Government funds	**2410**	**14**
Private financial institutions	**4720**	**25**
Total	***9280***	***43***

Table 4-2: CER acquisition programs. Sources: public announcements of budgets, programme websites. Note that most of the programmes also acquire Emission Reduction Units from Joint Implementation projects

Beyond the pure compliance regime of CERs, there are two market segments with a voluntary character. The first is the "Gold Standard", which has been developed by a coalition of NGOs and aims to guarantee a high contribution of projects to sustainable development and an intense participation of local stakeholders. By February 2009, 10 Gold Standard projects had been registered, while 89 were in the validation pipeline.

The pure voluntary market can generate some demand for CERs. So far, this market has been characterised by a lack of oversight and credits of greatly variable quality. The UK government has recently defined a standard for voluntary offsets which limits voluntary offsets to CERs and ERUs.

The contribution of the CDM to technology transfer has been assessed in several studies. Haites et al. (2007) assessed a sample of 854 projects submitted for validation before July 2006, and found that about one third of these projects – accounting for almost two thirds of CER volumes – involve technology transfer. Technology transfer varies widely across project types and is more common for larger projects and projects with foreign participants; it seems to be relatively independent of host country size or per capita GDP. Equipment transfer is more common for larger projects, while smaller projects involve transfers of both equipment and knowledge, or of knowledge alone. Dechezleprêtre et al. (2007) analyse a sample of 644 projects registered before May 2007, and find that technology transfers occur in 44 % of the sample, accounting for 84 % of the expected CER volume.

Yet the impressive numerical progress of the CDM hides substantial challenges which are mainly linked to its environmental integrity. Other challenges relate to long-term incentives for developing countries to introduce emissions mitigation policies and eventually take up binding commitments. These will be discussed below.

4.1.2 The additionality challenge

Due to the fact that host countries of CDM projects have no emissions budget, they have an incentive to generate as many CERs as possible in order to maximise revenues. CER buyers are also interested in a large CER supply at low prices. So everybody would be happy if projects generate CERs, which would happen anyway – except for a few environmentalists who want to avoid “paper credits”. Therefore, it is an uphill battle for regulators to limit CER generation to those projects that are only mobilised through the CER revenue, i.e. projects that are “additional” to business-as-usual. The concept of additionality lies at the heart of the CDM and has been one of its most contentious issues. Ever since the agreement on the Kyoto Protocol, project developers, researchers, NGOs and CDM regulators have fought over the interpretation of additionality.

While business representatives have argued that the intent of project developers cannot be judged and that any project with emissions below the baseline is automatically additional, NGOs have proposed that only projects, which would not be profitable without sale of the CERs, should be seen as additional. This conflict was not resolved until 2003, as regulators replicated the ambiguous wording of the Kyoto Protocol. It was only in 2003 that the CDM Executive Board mustered the courage to specify principles for checking additionality, starting with the idea that small-scale projects must show that they face barriers.

The submission of the first large-scale baseline methodology proposals led to the definition of the consolidated additionality tool, as it became clear that specification of the baseline cannot determine additionality. The tool includes a series of checks, starting from identification of baseline scenario alternatives. Projects can either apply an investment analysis to those alternatives, and show that the project is not the most attractive option, or show that the project was forced to use the CDM in order to overcome prohibitive barriers. Finally, it must be shown that the project does not reflect common practice in the region.

Despite the repeated statements of the Conference of the Parties, that the tool is only a voluntary instrument and that other approaches for additionality determination are also possible, the tool is now universally applied. In the first two years of registration of CDM projects, most project developers applied the additionality test in a cursory manner and validators did not use external sources to check the credibility of the statements. When regulators realised this, they introduced the Registration and Issuance Team to double-check project documents and validation reports.

This led to the first rejections of projects on grounds of lack of additionality. Moreover, the UNFCCC Secretariat commissioned reports on the quality of additionality testing. From 2007 onwards, critical research reports about the lack of additionality (Michaelowa and Purohit, 2007, Schneider, 2007), which were widely reported in the media, spurred another round of tightening of additionality determination. The rejection rate increased. For the first time, the “serious consideration“ of the CDM before project start was assessed, leading to the first rejections of projects which could not show that the CDM played a role before project start. As project developers and validators complained about inconsistent decisions with respect to additionality determination, guidance regarding investment testing was developed. With the Validation and Verification Manual, a further streamlining of procedures has been achieved.

Nevertheless, the interpretation of additionality continues to be a fight between cunning project developers and regulators who try to close loopholes as soon as they are recognised. This is exacerbated by the tendency for CDM projects to be financed from host country resources. This so-called “unilateral” financing represents an attempt to “whitewash” existing investment plans as CDM projects. Project developers carry the full risk of the CDM project cycle. As discussed by Lütken and Michaelowa (2008), companies from industrialised countries shy away from actually investing in CDM projects, preferring to buy CERs on the primary or secondary markets, which does not expose them to any project risk.

Given the increasing strain on the regulatory system due to the increasing share of non-additional projects and loss of trust in the CDM by policymakers and the general public, an "integrity first" strategy should be built, providing the right incentives to project developers. Validators would no longer be hired by project developers, but allocated by the EB and paid according to a fixed-fee scale. DOEs should bear all costs of request for review and review procedures for projects they have validated/verified. Review of a project should automatically lead to a spot check of the DOE which validated/verified the project, which should bear all costs of that spot check.

A rejection of a project by the EB should lead to an automatic suspension of the DOE if the EB finds that the DOE acted in a fraudulent or incompetent manner. EB members would enjoy legal immunity so they could not be pressurised by large project developers. The barrier test should be made much less subjective than today, by specifying when a barrier is prohibitive. This would address all problems at once: higher quality projects would generate fewer requests for reviews and thus allow the Board to concentrate on strategic issues. Policymakers would face less public pressure to limit CER imports. Furthermore, the inflow of new CERs would be reduced, which would reduce the probability of a price crash.

4.1.3 Does the CDM slow the introduction of developing country mitigation policies and commitments?

The existence of the CDM allows host countries to generate revenues from projects mitigating greenhouse gases. Without the CDM, countries might have had an incentive to introduce mitigation policies. A reason for the introduction of such policies would be the capture of externalities from greenhouse gas reduction – such as reduction of local pollutants – which improves public health.

A policy subsidising or mandating mitigation could theoretically be interpreted as business-as-usual and thus projects mobilised by this policy would not qualify for the CDM. Therefore, host countries could be deterred from introducing policies, or might even have an incentive to subsidise greenhouse gas emissions, in order to increase the CER generation potential of projects. Regulators recognised this problem early and introduced a rule which specifies that policies promoting mitigation that were introduced after 2001 should not be reflected in the baseline. Likewise, policies enhancing greenhouse gas emissions introduced after 1997 should be ignored in the baseline. This decision has, however, not been reflected adequately in the detailed CDM rules. New mandatory policies, e.g. for landfill gas capture, do change the baseline, whereas subsidies for renewable energy are not considered in the additionality test, for example in South Korea. Therefore, there is a deterrent to mandatory policies. The regulators should remove this inconsistency as soon as possible. Excluding the subsidy from the additionality test is not problematic, as the projects mobilised through the subsidy would not have been viable without the subsidy, or would not pass the additionality test if they were already viable in the absence of the subsidy.

In the long term, de facto crediting of policies is a deterrent to uptake of emissions commitments, because a country loses all its revenues from CDM when it takes up a commitment. Thus, a discount of emissions credits from projects hosted by advanced developing countries should be introduced. The higher the degree of development of a country (e.g. determined by per capita income and emissions), the higher would be the discount of CERs generated by a project in that country. For example, a tonne of CO_2eq. reduction in Qatar could only yield 0.1 CERs, whereas in China it would generate 0.6 CERs and in Tanzania 1 CER. With the discount, it becomes attractive to take up a commitment since any reduction achieved through a project under the commitment counts 100 % and can be sold through emissions trading, whereas staying with the CDM means a loss of revenues. Discounting would also address the additionality problem on a macro level but would not provide an incentive to submit only additional projects.

Discounting should not touch existing CDM projects as it would otherwise be akin to expropriation and would therefore be a deterrent to future investment in CDM projects. After registration of a CDM project, the project should always generate CERs according to the rules that were in force at the time of registration. Obviously, discounting would influence the level of CER supply. Given that even today political decisions (such as the integration of certain project types in the CDM) have a strong impact on supply, a discount rate fixed for the duration of a commitment period would not have an unusually strong effect on supply unless it is prohibitive for certain host countries.

As a remedy for the problems generated by project-specific assessment, sectoral approaches have become fashionable. There are many different design options for sectoral CDM. Most of them are based on a benchmark, which defines the baseline emissions factor. The exact definition of the benchmark depends on: the system boundary, the indicator used for the benchmark, the companies/plants to compare against, and the stringency of the benchmark. Benchmarking is much more data-intensive than project-specific approaches. Deciding on the stringency level of a benchmark is very challenging; it might be just as subject to gaming as project-based baseline setting. A too-stringent level will eliminate incentives for project developers, while an undemanding level leads to the creation of CERs which are not backed by real emission reductions. In this context, a double benchmark concept has been proposed, with a more stringent benchmark for additionality than for the baseline emissions factor. The institutions developing benchmarks must incur significant costs for benchmark development, while individual project developers would benefit due to reduced transaction costs. Solutions will have to be found for dealing with confidentiality of data. In general, sectors appropriate for benchmarking produce goods or service identical in their nature and in their production processes, are highly concentrated, have no geographic factors distorting the level of performance, and already have a large amount of available data.

The EU Commission has recently proposed a sectoral crediting mechanism to replace the CDM. A group of installations, ideally covering a whole industrial sector, would have an emission target that is below its business-as-usual emissions. If it reduces emissions below the target, it will be given credits equal to the difference between the target and actual emissions. But there will be no penalty if the targets are not met. The targets would most probably be set through benchmarking. The EU sees the power, cement and steel sector as the most likely candidates for such sector crediting. As is the case for CERs today, the sectoral credits generated could then be used for compliance with targets under a new climate policy agreement and sold to companies covered by the EU ETS.

4.1.4 Further challenges for the CDM

Even if the additionality problem and the disincentive to take up commitments are resolved, several issues impacting on the efficiency of the CDM remain. Some of them are linked to the overall design of international climate policy, others relate directly to the mechanism.

A common criticism of the CDM is the volume of financial transfers to developing countries. It would not politically feasible to transfer billions to developing countries instead of spending that money domestically, where positive externalities would be generated. An expanded version of this argument is that low-cost foreign competitors of domestic industries are subsidised. As studies (see overview in Pittel and Rübbelke, 2008) show that the externalities related to domestic emission reduction are lower than the differential between domestic abatement costs and the price of CERs, this argument is not supported by economic reasoning.

A second criticism is that the CDM is inefficient as it leads to high rents for project developers, which could be avoided through an approach whereby an emissions abatement fund finances only the marginal abatement costs of the mitigation technologies (cf. Wara and Victor, 2008). This argument implicitly assumes that the rent should be captured by the user and not the generator of an emission reduction project. Experiences with the financing of "incremental costs" of emission reductions by the Global Environment Facility show such an approach is extremely bureaucratic and does not provide sufficient incentives to actually harness emission reductions.

Finally, there is a criticism that argues that the CDM subsidises carbon leakage from industrialised countries, as industries have an incentive to shut down production in industrialised countries and to set up new production plants in developing countries. As these new plants are more efficient than a business-as-usual plant in a developing country, they would be entitled to CERs. The incentive to move production is not generated by the CDM but by the industrialised country's own commitments. If the commitments of industrialised countries could be adjusted for leakage, the CERs would only constitute a marginal incentive which would not be sufficient to cover the costs of relocation. So far, the CDM has not supported greenfield industrial production plants in developing countries to any extent; the overwhelming majority of large-scale energy efficiency projects in industry have been implemented for existing production facilities.

A related criticism argues that the CDM subsidises carbon-intensive activities with CDM credits, rather than making them more expensive, to facilitate a shift to low-carbon sectors in developing countries. For example, Sreenivasamurthy (2008) argues that CDM revenues prevent Indian steel producers from shifting from highly carbon-intensive direct reduced iron process to the more efficient blast furnace process. This argument is only partially correct, as taking up the more efficient production route would generate more CERs than would be earned by simple waste heat recovery from a very inefficient process.

In either case, the financial support the CDM credits provide to steel producers will result in a reduction of steel production costs, and thus reduce steel prices. In contrast, full carbon pricing, e.g. through emission trading with auctions or carbon taxes, increases steel costs, and thus creates incentives to use steel more economically and substitute less carbon-intensive materials.

Any climate policy instrument linked to output – be it emissions trading, the CDM, a voluntary agreement or a technology subsidy – in that it has an implicit grandfathering component which will reward existing polluters who upgrade their production. However, the CDM provides a strong incentive for greenfield plants, as the high share of renewable energy plants in the CDM project pipeline shows. As long as developing countries do not have mandatory emissions targets, policies that achieve carbon pricing throughout the economy are unrealistic and thus the CDM is a second best solution which mobilises reductions efficiently as long as projects are additional.

Regarding the quantitative potential of the CDM to contribute to the post-2012 climate policy regime, there is a wide range of views. Pessimists argue that the CDM would be unable to deliver the several billion emission credits that would be required to cover the deficits of industrialised countries under a 40 % reduction scenario for 2020. Optimists counter that the CDM has delivered a much higher credit volume than anticipated and can easily be upscaled to include demand-side management in industry, households and transport.[19] In fact, regulators have recently approved several methodologies which could lead to a breakthrough in these areas. So far, policymakers in industrialised countries seem to fear an oversupply of cheap credits from the CDM, and thus currently all industrialised countries except Australia limit imports of CDM credits.

4.1.5 Summary – why a second-best project crediting mechanism is a key element of the future climate policy regime

The CDM is clearly not the optimal climate policy instrument. It would be much better to have a global emissions trading system which penalises greenhouse gas emissions everywhere and generates a global price signal. Unfortunately, differences in national wealth and salience of the climate change problem will lead to a situation in which a substantial share of the world's countries does not take up mandatory emissions commitments and thus remains outside of an emissions trading system for decades to come. To mobilise emission reductions in these countries, a project-based crediting mechanism offers one option. To safeguard the environmental integrity of the system, intensive regulatory oversight is required, based on the principle of additionality. This regulation necessarily leads to transaction costs and cannot be fully streamlined. As countries develop and become richer, there must be an incentive not to remain addicted to the revenues from the project-based crediting. This can be provided by discounting of emissions credits linked to the degree of development of a country. Policy consultants and economists will have to evaluate which levels of discounting provide sufficient incentives to "graduate".

19 The IPCC 4th Assessment Report estimates the emission reduction potential in developing countries with a marginal cost of less than US$20 at 7 bn t per year for 2030, with $3 bn for the buildings sector alone (see IPCC 2007).

4.2 Creating a global carbon market by linking systems

Authors: Christian Flachsland and Andreas Türk

Today, a multitude of emissions trading systems are in co-existence and are emerging, such as the Kyoto Protocol's flexibility mechanisms including the CDM, the EU ETS, and other domestic cap-and-trade initiatives in OECD countries. Furthermore, new carbon market mechanisms – including sectoral approaches for developing countries that would include major emitters like China and India – are also currently under intense discussion.

This chapter addresses the question of how international carbon markets could evolve after 2012. For example, the European Union has formulated the vision of a global carbon market and proposes this as a major instrument in the global effort to limit global warming to 2°C (EU Council, 2007). Section 4.2.1 introduces basic concepts and three scenarios for the future of the international emissions trading architecture. Drawing on results from the model comparison exercise, we investigate quantitative implications of international emissions trading by 2030 and 2050 in Section 4.2.2. We discuss the general pros and cons of an increasing integration of carbon markets and analyse the implications of specific linking scenarios in Section 4.2.3. Finally, plausible timeframes for developing an international carbon market are identified in Section 4.2.4.

4.2.1 Concepts and scenarios

Before discussing three stylised scenarios for the further development of an international emissions trading architecture, some key terminology is introduced to facilitate the discussion. Cap-and-trade systems set a binding, absolute cap on total emissions, but allow for allowances to be traded among covered entities, which are either *nations* or *companies*. The Kyoto Protocol trading system for Annexe-B countries is an example of cap-and-trade at the government level, while the EU ETS operates on the company level. In contrast, credit schemes define a certain baseline such as (a fraction of) business-as-usual emissions or intensity benchmarks, allow emission reductions relative to this baseline to be sold as credits. The CDM and JI mechanisms established under the Kyoto Protocol are examples of such credit schemes.

Two or more emissions trading systems can be linked, either *indirectly* or *directly*. Indirect links occur if two trading systems are both linked to a third system, e.g. the CDM market. This can lead to price convergence across the indirectly linked systems. For example, the EU ETS and the Kyoto AAU[20] trading system are indirectly connected via the CDM. Direct links, by contrast, allow direct trade between different schemes and can be distinguished according to whether they allow trading in only one or more directions. In a full *bilateral* link, allowances can be freely traded between two systems and each system's allowances are equally compliant in these regions. If more than two schemes are participating, this becomes a *multilateral* link. Under a *unilateral* link, entities in system A can purchase and use allowances from system B for compliance, but not vice versa (Mehling and Haites, 2009). If A's allowance price is higher than B's, entities in A will purchase allowances from B until the systems' prices converge at some intermediate level. If A's price is lower than in B, there

[20] The Kyoto Protocol established an accounting system where countries are required to hold allowances – called Assigned Amount Units (AAU) – corresponding to their emission budgets agreed under the Protocol.

is no incentive for inter-system trading (Jaffe and Stavins, 2008). For example, the EU ETS features a unilateral link to the CDM mechanism.

Building on these basic distinctions, we identify three potential options for international emissions trading post-2012.[21]

A *Kyoto-type* approach continues with the principle of targets defined at the national level. Governments that do not meet their target can buy AAUs from countries which reduce emissions beyond their target. Developing countries can participate by selling some type of credits, generated, for example, though a reformed CDM or new sectoral mechanisms.

Company-level cap-and-trade systems, such as the EU ETS or a future federal US trading scheme, can establish *direct bilateral links* (EU Commission 2009a, ICAP, 2007). Several countries are currently considering the introduction of domestic cap-and-trade, including Australia, New Zealand, the USA, Canada, Japan and South Korea. These systems can be linked in the absence of a Kyoto-type agreement, or within such a framework. In the latter case, governments would devolve trading activity to the level of companies, and trade only on behalf of sectors not covered by domestic ETS (Hahn and Stavins, 1999; see Figure 4-19 for an illustration of this architecture). In fact, this is the approach adopted by the European Union in the First Commitment Period of Kyoto Protocol 2008-2012, where international allowance trades between companies within the EU ETS are mirrored by transfers of Kyoto allowances in country registries (Ellerman, 2008). In 2007, several governments inaugurated the International Climate Action Partnership (ICAP), a forum aiming at exploring opportunities and barriers to linking emerging regional cap-and-trade systems and to work towards the establishment of a global carbon market (ICAP, 2007, Bergfelder, 2008).[22] Equally, in an international sectoral approach, sectoral cap-and-trade systems targeting e.g. sectors particularly affected by leakage concerns (such as cement, steel, aluminium; see Section 2.2) can be linked, thus creating a better integrated international carbon market.

Indirect links of regional cap-and-trade systems might emerge as the de facto architecture of international emissions trading after 2012, at least for an intermediate period and in particular if a Kyoto-type agreement does not materialize (Jaffe and Stavins, 2008). Such indirect links would be deemed to have emerged if at least two regional cap-and-trade systems accept permits from the same credit scheme, e.g. the CDM or some new sectoral mechanism. Depending on market conditions, indirect linking would lead to a complete or incomplete convergence of the allowance prices in indirectly linked cap-and-trade markets. The basic mechanism is illustrated by the following example: consider two cap-and-trade systems with pre-link autarkic allowance prices of €20 and 30 Euros. If these simultaneously link to a credit system with an unlimited supply of credits at €10, and place no restriction on this link, their prices will converge at €10. All of the existing and emerging cap-and-trade systems

[21] See Flachsland et al. (2009a) for a more detailed treatment of these issues.

[22] CAP members are the EU Commission and several EU Member states, several US states from both the Regional Greenhouse Gas Initiative (RGGI) and the Western Climate Initiative (WCI), and Australia, New Zealand, Norway, as well as the observers Japan, the Tokyo Metropolitan Government, and Ukraine.

foresee links to the CDM, often with some qualitative and quantitative restrictions. If the CDM or new crediting mechanisms play a strong role in an international architecture post 2012, it can be expected that indirect links will emerge even in the absence of direct co-operation between different regional carbon markets.

These scenarios offer three options for integrating developing countries into international emissions trading. First, CDM-type crediting schemes may be continued and expanded. Given the shortcomings of CDM, this is a highly controversial option (cf. Section 0). Second, developing countries may agree on sectoral no-lose targets or other sectoral crediting mechanisms. Emission reductions below some baseline would be credited and could be sold in an international market, but no penalty would apply if the baseline were exceeded. Baselines might be intensity targets such as emissions per unit of production (for example per MWh of electricity or tone of cement), but given uncertain projections over business-as-usual developments and the distributional implications of setting baselines, their precise implementation would be challenging. Third, developing countries could adopt absolute targets, both economy-wide and on a sectoral level. However, in recent years developing countries have rejected this approach for any international framework pre-2020.

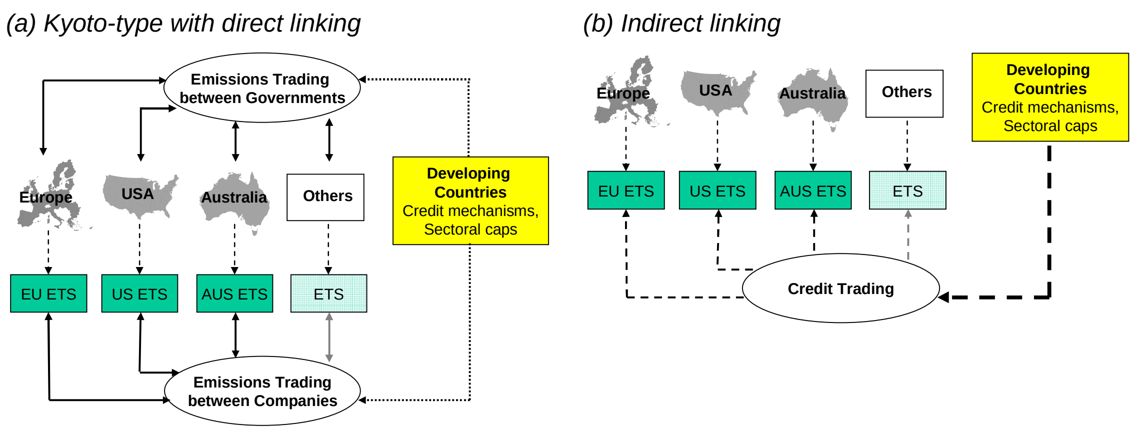

Figure 4-19 a-b: Scenarios for international emissions trading. Figure (a) displays how Kyoto-type trading on the government level can be combined with direct linking of domestic trading systems. Figure (b) illustrates indirect links that emerge if regional cap-and-trade markets enable imports from the international credit market.

4.2.2 Quantitative implications of global emissions trading

For any initial allocation of allowances, regions will trade allowances until a single optimal regional emission profile is attained. That is, regional emissions are independent of the initial allocation of allowances. A deterministic optimisation model featuring emissions trade results in separability of efficiency and equity (Luderer et al., 2009). This implies that the volume of international permit trade flows crucially depends on the deviation of initial permit allocations from the optimal regional emission profile. The larger the deviation of the allocations, the larger the permit flows. Also, it was shown that the distributional outcome from specific allocation schemes varied significantly across models. In this section, we further analyse international allowance trade flows in 2030 and 2050 for the Contraction and Convergence (C&C) allocation case, to illustrate potential orders of magnitude in international permit trade. We analyse trade volumes in terms of allowances as well as associated financial flows.[23]

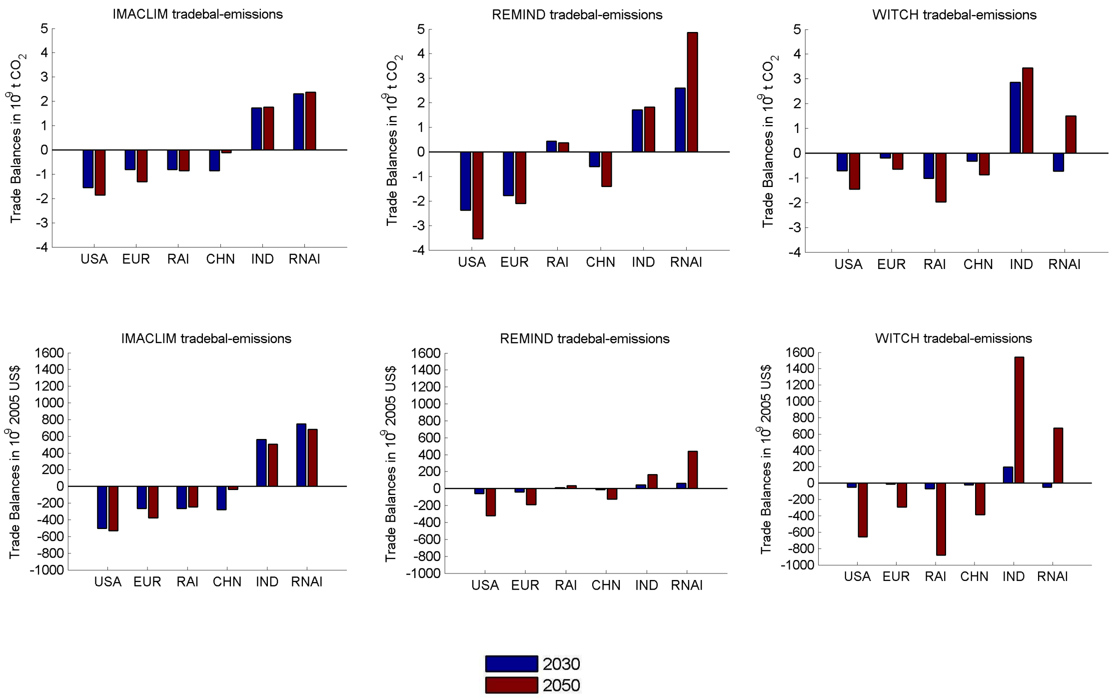

Figure 4-20: Regional allowance trade balances (upper row) and financial trade values (lower row) for the years 2030 (blue) and 2050 (red) in the models IMACLIM-R, REMIND-R and Witch.

For the C&C rule, the European Union is a net importer of allowances in 2030 and 2050 in all three models. Its maximal import amounts to 2.1 Gt in 2050 in REMIND-R. In financial terms, IMACLIM-R calculates US$376 billion as the maximum EU expenditure for permits on the international carbon market, corresponding to 1.1 % of EU GDP in that time step. EU expenditure for permits in 2050 in terms of GDP is 0.8 % in WITCH, and 0.56 % in REMIND-R. To put these numbers into perspective, the share of OECD countries' oil expenditure as a fraction of GDP was in the range of 1-5.5 % from 1980 to 2008 (IEA, 2008a: 102).

For C&C, India seems set to receive substantial income from selling permits in IMACLIM-R and WITCH. Allowance sales revenue in 2050 amounts to $1542 billion in WITCH, $507 billion in IMACLIM-R, but only $164 billion in REMIND-R (these values correspond to 10 % of Indian 2050 GDP in WITCH, 4.4 % in IMACLIM-R, and 1.75 % in REMIND-R, respectively). These substantial differences across models underline the structural uncertainty about the expected orders of magnitude of international carbon finance flows. The differences across the models largely depend on the strongly differing level of the permit price, which depends on the flexibility of the global energy system assumed by the models (cf. Luderer et al., 2009).

[23] Financial flows in permit trade are simply trade volumes times the permit price.

These figures highlight that carbon finance would become a significant source of revenue for developing countries. As argued, e.g. by Collier (2007), large revenue streams from a resource like oil – or emissions permits – can have a detrimental impact on economic development due to the so-called "Dutch disease": revenue volatility and erosion of governance practices. Therefore, if some countries expect substantial permit sales, careful institutional design for administering these revenues will be in their interest.

The differences of results across the three models highlight the uncertainty over financial flows associated with international emissions trading. Luderer et al. (2009) showed that this uncertainty also extends to the international distribution of mitigation costs, where the three models compute different burden-sharing outcomes for identical allocation regimes. Obviously, an outcome-based view of burden-sharing in the context of an international trading regime would remain exposed to uncertainties from real-world negotiations. We note, however, that uncertainties also prevail over domestic mitigation costs, and that other approaches to support developing countries in their implementation of low-carbon development strategies also face some challenges, as will be discussed in more detail in the next section.

Another way to address uncertainties about burden-sharing in an international allowance trading scheme would be to simply move away from an outcome-based view of burden-sharing to an allocation-based view, where only the fairness of allocation rules would be negotiated but not the associated welfare implications. Yet another option is to negotiate long-term emission budgets only on a *global* scale in order to stabilise expectations, while determining *regional* allowance endowments for shorter time-spans only, thereby allowing for learning over key parameters, and updating regional budgets according to a fundamental burden-sharing rule.

This discussion underpins the value of creating stable expectations and developing a low-cost mitigation technology portfolio to contain the value of scarce emission rights. As visible from the results of REMIND-R – an inter-temporal optimisation model with high technological flexibility – the scope for conflicts that are inevitably associated with distributing the scarcity value of emission rights is reduced if allowance prices need not rise high to meet ambitious stabilisation objectives.

4.2.3 Pros and cons of linking

This section considers the major pros and cons of linking emissions trading systems to create an integrated international carbon market. We first discuss generic pros and cons of linking of emissions trading systems, before turning to the more specific implications of the scenarios outlined in the previous section.

In general, the major economic benefit from linking any type of emissions trading systems derives from the efficiency gains from enabling trade across systems with different marginal abatement costs (allowance prices). Also, smaller carbon markets should benefit from improved liquidity when linking to other systems. Larger markets created by linking smaller systems feature more players and thus reduce concerns over market power. In addition, concerns about leakage resulting from different carbon price levels, between countries that have linked their schemes and therefore harmonised carbon prices, are eliminated. This does not address concerns about leakage towards third parties that are not part of the linked scheme. The expectation of future linking of schemes can deliver much of this advantage as it reduces the benefits from any potential relocation of production if the carbon price differential is expected to vanish within a short time-frame. In political terms, linking trading systems can be seen as a way of signalling commitment to multilateral climate change policy, which is crucial for achieving significant cuts in global emissions associated e.g. with the 2°C objective. Possibly the most important impact of implementing a well-functioning transatlantic link between a US cap-and-trade system and the EU ETS (Sterk et al., 2009), for example, may lie in demonstrating the feasibility of this approach vis-à-vis other major developing country players such as China and India, which could eventually join such a regime. Without transfer mechanisms, as embodied in international emissions trading, it is questionable whether developing countries will agree to significant emission cuts.

However, the decision to set up joined trading systems also requires a number of caveats. As noted by Babiker et al. (2004) and Paltsev et al. (2007), in second-best settings there may be situations where linking is not always beneficial for *all* linking partners. Maybe most importantly, linking partners must accept each other's cap trajectories or baselines (in credit schemes), as these determine the distributional outcome when enabling trade across regions. If one player adopts a non-ambitious cap or baseline it can benefit disproportionately from selling allowances internationally. This issue is complicated by the uncertainty over distributional outcomes from international emissions trading which was illustrated above. In addition, if some linking partners envisage certain minimum carbon price levels for fostering R&D, or would like to avoid very high allowance prices to contain costs, it would have to be ensured that these price objectives are not violated when linking. For example, setting an large cap in one region will drive down allowance prices within the entire linked carbon market. Also, if governments want to achieve some level of abatement domestically and intend to ensure that abatement investments are undertaken within their economy – to reap perceived co-benefits such as reduced fossil fuel imports and the creation of green jobs – this can be a barrier to linking.

Also, prior to linking two schemes, basic consensus on their design, MRV requirements and compliance mechanisms is required. Generally, international integration of carbon markets reduces domestic regulators' unilateral control, pointing to the need of some joined institutional framework for carbon market governance (Flachsland et al., 2009b).

In addition to these generic issues, we identify a number of pros and cons concerning the three particular carbon market architectures considered in the previous section:

A major advantage of the *Kyoto-type* approach is that it facilitates international negotiation of regional levels of ambition in terms of emission caps. If major emitters adopt caps or at least have clear incentives for reducing emissions from their baseline, this can mitigate concerns over carbon leakage, enabling a higher level of ambition for the aggregate reduction effort, compared to the case of uncoordinated regional climate policies. Thus, a Kyoto-type trading scheme may facilitate the adoption of an ambitious climate policy framework that corresponds to the 2°C objective. However, in case of stalemate in negotiations over regional caps, this approach cannot be implemented. Another concern is that government-level emissions trading is prone to economic inefficiency due to market power (Böhringer and Löschel, 2003)[24], and the

[24] Only three countries, USA, Russia, and Japan, accounted for 57 % percent of Annex-I GHG emissions in 2005 (CAIT 2008)

question of whether governments are generally able to act as cost minimisers on carbon markets, given e.g. their geopolitical interests (Hahn and Stavins, 1999). Finally, we illustrated the differences in distributional outcomes of allocation regimes across different models, reflecting underlying uncertainties about parameters and system properties. This further complicates negotiations over burden-sharing in the context of international emissions trading. However, it should be taken into account that a substantial part of this uncertainty also arises in the absence of emissions trading, and that in the absence of international transfer mechanisms, ambitious global reduction objectives as implied by 2°C will very likely be unfeasible.

Regarding *full bilateral links between regional cap-and-trade systems* in the context of a Kyoto-type system, these promise to mitigate the economic efficiency problems of the latter as they entail devolution of permit trading from government to company level. This is because firms can be expected to act as cost minimisers and will be less able to exert market power than governments. Concerning pros and cons of bilateral links in the absence of a Kyoto-type agreement, all the generic arguments outlined above apply.[25]

Concerning *indirect linkages*, their major advantage is that they do not require complex international co-ordination efforts. As an intermediate architecture, indirect linkages may achieve cost savings by harmonising regional carbon prices. As a downside, the indirect linking approach does not facilitate negotiations of a comprehensive agreement addressing equity issues, and fails to provide a perspective for development towards a future integrated and stable international carbon market. If price harmonisation and mutual influence of emissions trading systems are considered detrimental e.g. because they lead to unacceptable changes in domestic allowance prices, this represents a drawback to indirect linking.

To sum up, the Kyoto-type approach offers the possibility of instantaneously co-ordinating emission reductions across a large number of countries. However, due to market power and the prominent role of governments in trading, it is unlikely to deliver maximal economic efficiency. Also, the inevitable setting of caps requires fundamental agreement on international burden-sharing, representing a substantial political challenge, particularly in the face of uncertainty. By contrast, direct and indirect linking approaches between regional trading systems allow postponement of a comprehensive multilateral distributional agreement. Direct bilateral linking requires linking partners to recognise each other’s cap trajectories, to rule out unacceptable distributional impacts. Also, both direct and indirect linking promise superior performance in terms of market efficiency, as they operate on the company level. However, these bottom-up approaches are less suitable for co-ordinating emission reductions across a larger number of countries, putting their short-term environmental impact into question. In this sense, they may be regarded as ‘fallback options’ to a broader Kyoto-type agreement.

Linking regional cap-and-trade systems in the context of an overarching Kyoto-type framework – an approach pioneered by the European Union – appears to be one plausible approach to international emissions trading after 2012, as it combines the possibility to negotiate ambitious regional emission budgets with setting up an efficient international

[25] For a more detailed treatment of the issues involved in bilateral linkages in absence of a Kyoto-type agreement, see Flachsland et al. (2009b).

carbon market. Clearly, substantial distributional and institutional questions need to be resolved to make this a viable policy option.

4.2.4 Timing

Assuming that a global carbon market will be a major instrument for delivering the 2°C objective, it would be desirable to have instantaneous implementation of a global trading system for companies, with a clear indication of the global reduction schedule at least until 2050, and including clear rules for a procedure for updating this schedule as new information arrives, as well as a globally accepted distribution rule for allowances at least in the short- to mid-term. In practice, a global carbon market can probably only be implemented step by step. To avoid leakage effects (cf. Section 2.2), substantial long-term differences in regional carbon pricing should be avoided, suggesting that at least major economies and emitters introduce comparable carbon pricing regimes as soon as possible.

The European Commission (2009a) has proposed setting up an OECD-wide cap-and-trade system by 2015, pioneered by a transatlantic EU-USA carbon market. It proposes that major developing countries join this international carbon market by 2020. Before adopting cap-and-trade, developing countries could implement large-scale credit schemes. As noted above, there are significant challenges to be overcome when implementing an international carbon market.

Given that the EU ETS is the only cap-and-trade system currently in operation and the prospect and timing e.g. for a USA cap-and-trade is still not certain, and that linking partners will want to observe single systems' performance for a few years prior to linking (e.g. ECCP 2007), the vision of an OECD-wide company-level carbon market by 2015 is ambitious. Clearly, an EU-USA carbon market would constitute the major share of an OECD-wide system and would send a strong political signal to stakeholders regarding the further development of international climate policy based on the construction of a global carbon market.

Concerning the integration of large emitters like China and India, it currently appears unlikely that they will sign up to binding caps prior to 2020. However, they may commit to do so by 2020, and implement large-scale crediting schemes in the intermediate period, to incentivise emission reductions and the flow of carbon finance.

Regarding the prospect for a Kyoto-type system featuring country-level caps and trade of allowances among governments, this could be implemented immediately at the 2009 Copenhagen negotiations and may start in 2013 to follow up on the Kyoto Protocol. Distributional issues, i.e. the determination of regional caps, are the major obstacle to agreement.

4.2.5 Conclusions

There are several building blocks for developing the international carbon market after 2012. They include first a *Kyoto-type* approach, with government-level cap-and-trade for industrialised regions and non-binding trading mechanisms such as a reformed CDM or sectoral mechanisms for developing countries. Second, both in the context, or absence, of a Kyoto-type framework, *direct bilateral linking of regional cap-and-trade systems*, e.g. of the EU ETS and other emerging schemes, is a viable option. Third, *indirect links among regional* *cap-and-trade system via crediting mechanisms* do not require international co-ordination and will emerge automatically if regional systems enable the import of credits.

While a Kyoto-type framework could be agreed at Copenhagen 2009 and come into force in 2013 to follow the Kyoto Protocol's first commitment period, links of OECD cap-and-trade systems cannot be expected to materialise much earlier than 2015. A transatlantic EU-USA carbon market might form the backbone of an OECD-wide cap-and-trade system, with subsequent enlargements. Until they adopt absolute caps by 2020, large emitters like China and India could adopt large-scale credit-based mechanisms for an interim period.

Depending on the rule for allocating emission rights across regions, international financial transfers may be significant, but there is considerable structural uncertainty about the order of magnitude of these flows. Carbon finance streams largely depend on the level of the permit price, which in turn depends on the flexibility of the global energy system.

4.3 International support for domestic action

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The discussion in this chapter pointed to the importance of a comprehensive set of policies that (i) internalise the carbon price, (ii) create conducive environments for the use of low-carbon processes, products and services, often at the sectoral level, and (iii) support innovation and technology development for low-carbon technologies.

The discussion on the future of the CDM mechanism (Section 0) illustrated the limitations of an instrument that primarily pays for incremental costs of low-carbon technologies, both by failing to address the other dimensions of low-carbon actions, and by potentially wasting large amounts of resources with an undifferentiated support level.

The discussion on linking using international carbon markets (Section 4.2) outlined options which also allowed for linkages towards developing countries, in particular by ensuring revenue streams to 'reward' participation and by using sectoral (no-lose) targets to avoid the use of an overall emission cap for a country. The authors pointed to the challenges of linking schemes which are emerging in developed countries and suggested that such linkages are unlikely to materialise before 2015. This suggests that linkages with developing countries might take even longer, given their more uncertain economic growth prospects and competing policy objectives, which prevent the necessary focus on developing the institutional infrastructure for robust emissions trading schemes.

This raises the question of how international co-operation can support domestic action with mechanisms that go beyond the scale and scope of the current CDM offsetting mechanism,

4.3.1 The role of domestic actions and policies

Domestic climate policies play an important part in shifting countries towards a low-carbon growth trajectory. This has been recognised in concepts such as Sustainable Development Policies and Measures, Technology Action Plans, and Nationally Appropriate Mitigation Actions.

The various barriers for the implementation of domestic policies with climate co-benefits are widely discussed in the literature. It is often the case that other government priorities and resource constraints restrict the scale, scope and speed of policy implementation. Their ultimate implementation will depend on the initiative of, and support from, domestic stakeholders. This can be driven by considerations of climate benefits, but is likely to be very dependent on the non-climate co-benefits.

Domestic producers of low-carbon and energy-efficiency technologies will support the shift from a support scheme for the initial deployment towards a regulatory framework that ensures the subsequent large-scale diffusion.

Co-benefits can ensure energy security, improve industrial profitability and competitiveness.

Energy is a bottleneck for growth: energy security has deteriorated, and substantial future demand suggests the incremental costs for the energy system are significant.

Co-benefits for low-income households can include accessing better energy services at lower cost

The successful implementation of domestic action will require more than just initiatives on the part of the domestic actor. Often the planned pursuit of very promising policies has failed at the later stage of execution. The experience of recent years has pointed to the role of intermediate indicators to facilitate the better management of policy implementation, and domestic and international learning about best practice. International frameworks – and their reporting under the UNFCCC – can create additional incentives for comprehensive measurements and can provide the opportunity for international benchmarking and best practice sharing.

4.3.2 Support for domestic action

Energy and the environment have been on the agenda of development co-operation and domestic policies for decades. This raises the question: why should domestic circumstances suddenly change – and what could help to unlock policies?

International support might be able to provide additional benefits for domestic stakeholders, and thus facilitate the implementation of policies.

International finance could provide a stimulus to address the lack of private investment and institutional barriers.

In many cases, policies and implementation mechanisms are in place but implementation is not occurring, suggesting a role for technical assistance. Benefits from transparent monitoring, as part of international reporting of actions by developed and developing countries, are possible.

Effectiveness, efficiency and equity are key considerations. Possible pairing of polices to remove other issues could align hard and soft policies to ease political and social implementation. Strong institutions are needed within a country to ensure domestic pairing, implementation and impetus.

The integration of key policy indicators across energy services, financing and private sector participation.

In parallel to the RECIPE project, which focused on the development of mitigation policies and actions in Europe, The International Support for Domestic Action (ISDA) ran workshops and case studies in five developing countries to assess how domestic initiatives and international co-operation could increase the scale, scope and speed of the implementation of policies with climate co-benefits. The results from the first phase are published as a special issue in the journal Climate Policy (Neuhoff, 2009). The following pages reflect the policy insights from the second phase of the project.

In international discussions on climate change cooperation four components are emerging.

1. Low-carbon development strategies: approaches initiated by South Africa and subsequently Mexico and South Korea outline the intended economic, energy and emissions trajectory for their respective countries. The overall strategy helps to identify trigger points for policy intervention.

2. Nationally Appropriate Mitigation Actions (NAMAs) comprise a set of projects, programmes and policies which shift a domestic sector or technology onto a low-carbon development trajectory.

3. International support mechanisms can provide tailored support for individual actions, to enhance the scale, scope or speed of their implementation. To address the specific needs of a country and sector, easily accessible mechanisms for capacity-building measures, technical assistance, technology cooperation and financial assistance are required.

4. Monitoring and reporting is necessary for the implementation of an action or policy, international learning, and transparency to enhance private sector investment and innovation. This requires detailed quantitative and qualitative evidence.

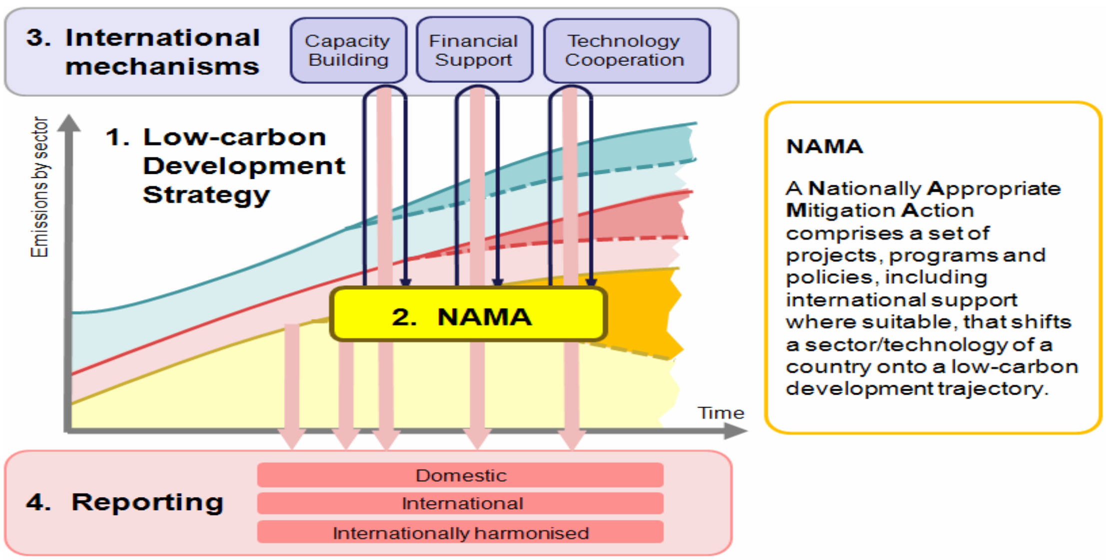

Figure 4-10: Components of international cooperation to support low-carbon development

4.3.3 Characterisation of mechanisms for co-operation

Analysis of the ISDA project points to the following aspects which could be of relevance for the design of the four component of international co-operation:

1. Low-carbon development strategies

Domestic ownership is essential for the success of low-carbon development strategies, to ensure that they capture the resources, capabilities and aspirations of a country. International co-operation can facilitate mutual learning and information sharing so as to ensure that low-carbon development strategies:

Provide frameworks for low-carbon transition in a country, avoiding the mere pursuit of marginal improvements on old technologies, but where possible allow 'leap-frogging' towards low-carbon technologies and infrastructure which have long-term mitigation and market potential. A clear framework that is supported with credible policies allows firms and investors to anticipate future market opportunities and to shift investments to low-carbon sectors and technologies.

Identify interactions across sectors to match energy supply - for example from biomass and renewable electricity production-– to energy usage patterns in industry, transport and households. Also, infrastructure needs can be met, e.g. by installing energy-efficient agricultural pump sets together with electricity metering, in order to facilitate efficient use of water and energy.

Align interests of domestic actors and the international community in developing a low-carbon development strategy which is consistent with domestic and global objectives. This requires that the plan not be taken as a commitment, but merely as a basis for the discussion of domestic commitments and international support for the implementation of NAMAs identified by the plan.

2. Nationally Appropriate Mitigation Actions

In parallel, a set of actions must be pursued, to facilitate a shift to low-carbon development of a sector or technology, including: training, capacity building, evolving institutional and regulatory structures, and initial access to finance. These require local knowledge and local stakeholders to initiate implementation, and gain political support.

The interest of stakeholders from government, academia, and often from industry and finance was demonstrated in country workshops pursued as part of the ISDA project. The initial interest was typically triggered by the co-benefits of low-carbon transitions: opportunities to improve energy access and security, create jobs, and achieve broader development objectives.

Opposition to change is to be expected from other stakeholder groups that benefit which the status quo or have a lot to lose. Political support can be increased, for example when incumbent companies participate in the deployment of new technologies, and if the transition of the workforce is supported with training. Long struggles to implement the policies to remove energy subsidies point to the importance of schemes that create win-win situations from change, e.g. combining price changes with investment support for efficient appliances.

It is desirable to define one NAMA for each transition in a sector or technology. The actions and associated politics for a low-carbon transition in any one sector or technology are complex; therefore further increasing the scope of a NAMA could delay delivery. The diversity of actions needed in such a transition requires involvement from many ministries and institutions in the design and implementation stages of a NAMA. Success hinges on high level political sign-up, to co-ordinate and pursue such actions.

3. International support mechanisms

International support mechanisms must be easily accessible by motivated domestic stakeholders, to allow domestic and international actors to structure support together. This ensures the support is demand-driven, incorporates local insights, and tackles the specific needs of the country and sector or technology. Different support mechanisms can create synergies for the implementation of a NAMA: Capacity-building enhances skills to manage, construct, maintain, and operate new technologies and practices that receive regulatory, financial and technical support.

International support can enhance the scale, scope and speed of implementation of NAMAs. If support is linked to individual NAMAs, it creates an additional driver for the domestic implementation of the actions required for success. Linking the support to continued NAMA implementation enhances the stability of regulatory and policy frameworks. For example, a feed-in tariff is more likely to be stable if international support contributes to the incremental cost over time. This attracts domestic and international manufacturing and investment.

Technology co-operation can support the development of a enabling environment for low-carbon technologies, encompassing technology innovation, human and institutional capacity, markets and regulatory frameworks, availability of finance, and focussed national policies. The type of support must be tailored to the state of development and diffusion of the technology, and to the country's needs. While the mechanisms often focus on co-operation between governments, their ultimate objective is usually the creation of an enabling environment for private sector innovation, deployment and use of the technologies.

The list of mechanisms proposed for technology co-operation is comprehensive. A subset of mechanisms must be developed and refined. Some mechanisms – such as R&D co-operation, technology-oriented agreements, intellectual property rights sharing agreements, and a global technology demonstration fund – focus on enabling new innovations. Other mechanisms, including a network of innovation centres and technical assistance, focus on the capacity to adopt, operate, and maintain technology.

Intellectual property rights (IPR) must be handled effectively. While they are neither the sole solution nor a dominant obstacle for technology co-operation, the current political focus on climate co-operation creates the opportunity to develop international institutional capacity to address IPR conflicts and facilitate co-operation on climate-relevant technologies. Industry standard bodies provide examples of how licensing and IPR disputes can be quickly resolved, while balancing expectations of returns for innovative activities with the needs of technology development and adaption to local circumstances.

Financial instruments matching the needs of actors and sectors facilitate the implementation of NAMAs. Grants, loans, credit guarantees or equity funding can thus support public and private actors in dealing with the risks of new technologies and policy frameworks, and create opportunities to acquire new skills and develop business models. International support for individual NAMAs can facilitate their implementation and enhance their long-term credibility. Public finance is therefore an essential catalyst to shift large volumes of private sector investment to low-carbon technologies.

The choice of financial instruments needs to reflect institutional capacity and available resources. Experience of bilateral and multilateral co-operation for specific financial instruments can inform the choice of institutions for their provision. The resource base of multilateral institutions can be strengthened with revenue from carbon pricing on international aviation and shipping. Commitment to hypothecation of domestic carbon revenues can create the public funds necessary for bilateral co-operation. If all support provided across all instruments is measured in grant-equivalent terms, developed countries' contributions can be measured against their commitments.

4. Reporting

Quantitative reporting must expand beyond greenhouse gas emissions, to facilitate effective management of the implementation of NAMAs and to allow for international learning. It can create accountability for all parties involved in international support mechanisms, enhance the credibility of the transition strategy and attract private sector investment. Experience from industry and other sectors points to the need to link outcome measures to a combination of input, process and output indicators.

The subsidiarity principle emphasises the value of local development of indicators, to match local needs, enhance domestic ownership and create greater political support. International registration of monitoring strategies and reporting is essential for the rapid international learning required to tackle the global problem.

Reporting of selected indicators and indicator categories must be agreed and internationally harmonised, allowing for international benchmarking to identify best practice, to ensure reports on international support mechanisms, to identify shortcomings, and to allow for accounting of international support provided by developed countries against their commitments.

4.3.4 Conclusion

International support can enhance scale, scope and speed of local implementation, if it tailored to these specific actions and if it is easily accessible. Case studies, explored as part of the ISDA project, show the implications for the design of mechanisms of international co-operation.

- If a subset of the mechanisms proposed for technology co-operation is developed and refined, it can support countries in creating an enabling environment for private sector innovation, deployment and use of the technologies.

- Public finance is an essential catalyst to shift large volumes of private sector investment to low-carbon technologies. Tailoring grants, loans, credit guarantees or equity provision to the specific needs of sector and technology can support public and private actors in dealing with the risks of new technologies and policy frameworks.

- Monitoring and reporting strategies are common practice in the public and private sector, to facilitate effective implementation of policies and actions. Expanding quantitative reporting beyond that concerning greenhouse gases furthermore facilitates international learning.

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