# Where can international cooperation support domestic climate policy?

Karsten Neuhoff[1]

*A move to a low Carbon economy involves (1) internalisation of $CO_2$ externalities, (2) advancement of technologies and (3) removal of barriers and evolution of institutions. National governments that want to realise these goals can choose from a menu of instruments the best suitable policy mix for their specific circumstances.*

*The paper identifies five objectives for international cooperation on climate policy that can support such national implementation. The Kyoto framework addresses all these objectives and provides a long-term perspective. In the mid-term the evolution of low carbon economies might be accelerated if countries or regions temporarily take leadership in climate policy. Governments might be prepared to accept more stringent emission reduction targets, if the penalty for missing the target is not defined in direct financial transfers to other governments via emission trading. While this creates some flexibility for international cooperation, countries do need to commit to instruments that result in price internalisation. As $CO_2$ costs are reflected globally in product prices, substitution effects to low Carbon products are facilitated and competitive disadvantages and emission spill-over is avoided.*

*JEL:* *D40, H23, O13, Q54*
*Key Words:* *Climate policy, international coordination, $CO_2$ internalisation*

## 1. Introduction

Macroeconomic models are frequently used to calculate the costs of climate policies.[2] Usually less than 1% of GDP is lost,[3] if atmospheric $CO_2$ concentration is stabilised at 450-550ppm.[4] Such low costs are achieved in the model if forward-looking agents

---

[1] I would like thank Jim Cust and Misato Sato for research assistance and David Newbery, Michael Grubb, Kirsty Hamilton, Andreas Loeschel, Roland Ismer, John Newman and Liz Hooper for helpful comments. Financial support from DEFRA and the UK research council project TSEC is gratefully acknowledged. karsten.neuhoff@econ.cam.ac.uk

[2] We focus on carbon dioxide as the most influential GHG

[3] For 550 ppm around 1% GDP losses are calculated by three of four models reported from comparison exercises of the Energy Modelling Forum (Kainuma et al. 2004; Mori and Saito 2004; Riahi et al. 2004) and 9 of 11 from the Innovation Modelling Comparison Project (Edenhofer et al. 2006). For 450 ppm 5 of 11 IMCP models calculate GWP losses of 1% or below (Edenhofer et al. 2006). Fischer and Morgenstern also conclude that perfectly foresighted consumers generate lower abatement costs (2003).

[4] 550ppm CO2 has been more widely studied in the economics community. However, many scientists have argued for a more ambitious goal that would contain risks, with reference to physical indicators

respond optimally to the challenges of climate change. Individuals and firms can make similarly effective decisions in our economies, if market failures are corrected with three sets of policies.

- Policies that ensure private agents **internalise the $CO_2$ costs** when making consumption, operation and investment decisions.
- Technology policies that support **development and initial deployment of low carbon energy technologies**, addressing the need to compensate private companies for technology and learning spill-over.
- Policies that address non-market barriers for new technologies and energy efficiency by **directly targeting barriers and institutional inertia** to minimise the costs of reducing $CO_2$ emissions.

While most of the policies can work on their own, synergies can be gained from joint implementation of policies to address all market failures. The paper has a section for each of the three policy sets. For each policy set the basic principles are introduced and recent experiences presented. Then the opportunities and benefits of international cooperation to support or facilitate national or regional policy initiatives are discussed. In principle such international cooperation does not need to restrain the flexibility national or regional policy makers have in addressing climate change issues.

In the specific case of $CO_2$ cost internalisation, two types of instruments are available. First, regulation that requires the use of efficient production technologies. Second, $CO_2$ taxation and some forms of emission trading ensure use of efficient production technologies and in addition reflect the cost of $CO_2$ in product prices. These price increases are desired because they induce industry and consumers to shift to low carbon products. But unilateral price increases reduce international competitiveness and could result in emission spill over. Both drawbacks are avoided if all countries agree to use instruments that reflect $CO_2$ costs in product prices.

National or regional targets defined in international processes are desirable. They addresses concerns about international fairness and increase commitment. This facilitates implementation, monitoring and management of policy success. Increased government commitment also supports private sector investment in low carbon technologies and energy efficiency.

The definition of long-term targets can be based on various metrics. Long-term targets are more effective if clear milestones facilitate monitoring of policy

---

such as adopted by the European Council of Ministers (2006) of limiting temperature increase to 2 deg.C, likely to require CO2 concentrations at 450ppm CO2 or lower.

success. Market confidence is increased if, in the short-term, all targets are translated into absolute targets.

Over the coming decades we need to reduce $CO_2$ emissions to a fraction of today's level. This puts the focus of current policies on creating the momentum that moves our economies along the appropriate pathway. Countries and regions can evolve in parallel exploring different instruments and solutions. To create space for this parallel evolution one might consider postponing a global market for $CO_2$ allowances. This might imply forgoing some arbitrage opportunities to target least cost abatement options. But in exchange it would simplify international negotiations by eliminating the 'threat' of large financial transfers from international $CO_2$ trading and by creating a focus on domestic capabilities and opportunities. Countries might thus aspire to achieve more ambitious emission reductions.

Different levels of $CO_2$ costs reflected in national policies or emission-trading schemes might distort international competition. Trade related measures like border tax adjustment might be able to create a level playing field in line with WTO objectives. This would allow countries or regions to show leadership with more stringent emission policies without risking competitiveness of their industry.

The participation of developing countries in climate policy is important, as they are expected to contribute to 39% of $CO_2$ emissions by 2010. The Clean Development Mechanism (CDM) is a first step to address some of these emissions - developed countries pay for the extra cost of low Carbon technologies on a project-by-project base. This not only reduces emissions but also creates capacity and awareness. Extending both the volume of investments and the scope to support broader policy spectra is desirable.

Such project-based mechanisms can only serve as a starting point for engagement of developing countries. They are expected to attract half of global energy investment over the next 25 years. If project based mechanisms were used to ensure that this investment is based on low Carbon technologies, then this would create excessive administrative efforts and thus undermine autonomy of national energy policy, the effectiveness of energy markets and the ability of developed countries to finance the projects.

Domestic climate change policies are also needed in developing countries. They can create additional benefits, for example in reducing energy import dependency. There is a long and not very successful history of domestic and international programs to reduce energy subsidies. This suggests that we need to explore innovative approaches to support countries in implementing domestic policies that move from subsidies towards policies that reflect $CO_2$ costs in energy prices and address non market place barriers.

Renewable energy technologies are produced at industrial scale, but most still require public support. Strategic deployment programs allow these technologies to become cost competitive with established technologies. They create international competitive markets to minimise costs and to allow monitoring of the technology performance. This enables governments to abandon unsuccessful technologies. As foreign technology companies can also sell and benefit from these markets, countries are reluctant to implement large strategic programs. International coordination on strategic deployment to support low Carbon technologies could address this free rider problem and might be complemented with increased public R&D and demonstration support. Such cooperation could also involve programs that make use of good renewable resources potentials in developing countries.

Addressing non-market place barriers for energy efficiency can offer a low cost opportunity to reduce $CO_2$ emissions. Some opportunities exist for international coordination on labelling and some energy efficiency standards. However, domestic policies are again core to address these barriers. Clearly defined national emission reduction targets offer the opportunity to monitor and manage the success of these policies.

## 2. Internalisation of $CO_2$ externalities

### 2.1 Basic principles

Various policy instruments are available to internalise $CO_2$ costs in economic decisions. The specific circumstances of each sector and each country are likely to determine which of the following instruments are best suited to achieve emission reductions:

*Regulation* can prescribe emission limits for specific technologies. Energy intensive industry pays attention to fuel costs. It is therefore likely to reduce wasteful energy consumption and associated $CO_2$ emissions. It might thus be difficult to design cost effective regulation for further improvements. In contrast, explicit are likely to be more effective where $CO_2$ emission are not related to cost of energy, e.g. process related $CO_2$ emissions and differences in $CO_2$ intensity between gas, coal and biomass. Other industry and consumers pay little attention to energy costs in many of their decisions and might also be slow to react to $CO_2$ price signals. Section four discusses how regulation could address the underlying non-market place barriers.

*Taxes* can either be targeted directly at $CO_2$ or indirectly at energy consumption. They are an established instrument and offer some stability to guide investment decision. It is politically difficult to implement them and to determine their appropriate level.

*Emission trading* sets a cap for emissions and creates a corresponding amount of allowances for $CO_2$ emissions. Allowances are then allocated for free or auctioned to emitters. Trading of allowances creates the flexibility to identify the least cost options for emission reductions and also defines a market price.

To facilitate the further discussion it is helpful to introduce the concepts of production internalisation and price internalisation.

*Production internalisation* reduces $CO_2$ emissions during the production process and aims to minimise the impact on the product price. An example is a regulation setting a maximum emission rate. It changes firms operational and investment decisions. Firms might for example be required to invest in $SO_2$ scrubbers to achieve an emission limit. Firms would then pass on the additional costs to the product price. But firms do not have to pay for the remaining emissions, and thus the product price increase is limited.

*Price internalisation* not only reduces $CO_2$ emissions during the production process, but also reflects the $CO_2$ costs in product prices. If firms for example have to pay taxes for $CO_2$ emissions, then they will both aim to reduce emissions during their production and also add the taxes they have to pay for remaining emissions to the product price. The increased product prices drive substitution effects, e.g. from cement to less $CO_2$ intensive building materials. Price internalisation can create large rent transfers, usually from consumers that pay higher product prices to producers that receive allowances for free or to the government that auctions allowances or taxes $CO_2$ emissions. Political support for a scheme can be increased if such revenues are recycled to reduce other tax burdens.[5]

## 2.2. Experience with $CO_2$ internalisation

Few instruments have been directly targeted at $CO_2$ emissions. Experience with instruments targeted at energy consumption provides insight because of their close link of energy consumption with $CO_2$ emissions.

*Regulations* formulating minimum energy efficiency requirements for appliances and houses or fuel efficiency standards for cars are widely applied. Yet the political and administrative effort required to agree on energy efficiency standards has so far limited the application to consumer products, insulation of houses and transport. Regulations do not offer the flexibility of market based instruments and could

[5] The importance of rent transfers is apparent when comparing the global annual value of anthropogenic CO2 emissions of $380 billion (at $15/tCO2) with the World Bank estimate of annual costs of mitigating Carbon Emissions of $60 billion (World Bank 2006).

therefore create larger costs than market based instruments if very tight controls are set on energy intensive sectors.

*$CO_2$ taxation* has so far only been implemented in Norway and indirectly under the Climate Change Levy in the UK. Proposals for CO2 taxation at the level of the European Union failed to gain sufficient political support. Experience from energy taxation suggests that more political support can be gained if revenue is recycled using tax rebates. Energy taxation directly changes energy prices and seems to be quite effective in reducing energy demand. Figure 1 illustrates that countries with twice the energy price level only require half the amount of energy per unit of GDP.

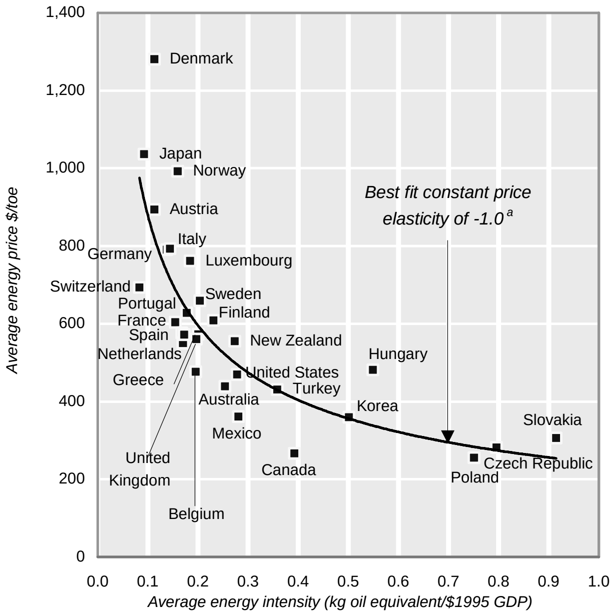


*Figure 1: Cross-section relation between average energy intensity and average energy price 1993-1999 (Newbery, 2003)*

*Emissions trading* usually enjoys more political support than energy taxation, because emitters covered by the scheme can be initially compensated through free allocation of allowances. With the allocation methodology governments can also choose whether they want to implement production internalisation or price internalisation. Let me explain:

Emissions trading is typically associated with the objective of price internalisation. Allowances are either allocated in a one-off decision at the outset of the scheme or are auctioned (e.g. most $SO_2$ and $NO_x$ programmes in the US). Producers can trade allowance surpluses or shortages. Thus they face the full costs of $CO_2$ emissions for every unit of production they sell, and will pass on the $CO_2$ costs through the product price,

Emission trading can however also be designed to be closer to production internalisation and limit price impact if it is directly linked to current production of firms. This is achieved if producers only have to provide allowances to cover emissions that exceed the emissions that efficient production would require to achieve the same output.[6] Alternatively, a benchmark is used to allocate allowances proportional to current production. Producers are then only required to buy allowances for emissions that exceed the benchmark rate. In both cases producers face very limited $CO_2$ costs when producing an additional unit, and therefore price impact is limited.

The European Emission-Trading scheme is located somewhere between production and price internalisation. Allowances are allocated iteratively for each trading period defined by the Kyoto process (e.g. 2005-2007, 2008-2012). Although this was not an intended consequence, this method does link allowance allocation to output and thus reduces opportunity costs of emitting $CO_2$. Allocations to new entrants create investment subsidies, further reducing the product price impact.[7] The repeated allocation process with repeated consultation processes tie up both government and private sector resources, distracting business from its focus on developing and producing innovative goods. They also result in various specific provisions in national allocation plans, which distort the effectiveness of the scheme.[8]

Investors currently ask for greater certainty about $CO_2$ prices throughout the payback period of new investment (e.g. 10-15 years). A combination of three approaches could address their concerns.[9] First, governments could commit early to targets or stringency of policy after 2012.[10] Second, governments could devise a clear and non-distorting process for allocation of $CO_2$ allowances. For example, moving away from free allocation should be possible once "old assets" have been compensated for the impacts of ETS. Auctions avoid distortions, implement price internalisation and create revenues to compensate consumers for higher product prices.[11] Third, governments can define a floor price for $CO_2$ allowances in the auctions starting 2008. This reduces risks for low-carbon investments.[12] The accelerated investment in turn reduces emissions and $CO_2$ prices.

---

[6] For example in the UK emission trading scheme (Smith and Swierzbinki 2006).

[7] For example, decisions on investment, operation and closure of plants are distorted if market participants believe that increasing CO2 emissions today will increase the amount of allowances that they will receive in future trading periods.

[8] Neuhoff et al. (2006) and Matthes et al (2005).

[9] A safety valve to prevent CO2 price spikes is frequently proposed (Aldy et al. 2004). While it might limit the impacts on the economy and thus also increase acceptability, it might also reduce rather than increase investment in low Carbon technologies.

[10] Newell et al. show how long-term targets together with banking stabilise prices (2005).

[11] Van Heerden et al. (2006) illustrate that in developing countries growth and poverty alleviation could be simultaneously pursued by using auction revenue to reduce food taxation.

[12] An additional argument for the introduction of price bands (upper and lower limits) follows from Weitzman's (1974) analysis of economic instruments under uncertainty. Applied to CO2 policy Pizer (2002) shows that price instruments (e.g. emission trading schemes) are usually preferable over quantity instruments (e.g. taxes), both are dominated by a hybrid approach. It seems however difficult to negotiate and verify price targets on an international level.

## 2.3 Challenges for internalising $CO_2$ in a multi-lateral world

Implementing unilateral policy to reduce national $CO_2$ emissions raises two sets of difficulties in our multilateral world.

First, national policy-makers might only consider the damage from climate change that can be avoided for their own country by policies that reduce emissions. If they ignore the damage that can be avoided in other countries, then they are likely to implement less stringent policies. Alternatively, policy makers might consider $CO_2$ emissions to be a global problem and might not act responsibly unless other countries do likewise.

Second, if only some countries implement stringent price internalisation, the international playing field for energy and $CO_2$ intensive industries will be an uneven one. For sectors that are both energy-intensive and exposed to international competition, investment might be shifted towards countries without price internalisation or with low $CO_2$ prices. This can put jobs and profits in countries with stringent $CO_2$ policy at risk and might result in emission spill-over. However, this effect is weakened as investment and closure decisions are guided by mid- and long-term expectations of cost differences. If market participants expect other countries to follow with similar policies, distortions from initial unilateral actions may be limited. $CO_2$ price differences may not create difficulties, as long as they are not persistent.

If a region expects to maintain higher $CO_2$ prices than its trading partners for a long period, policy makers will be concerned about competitive disadvantages for their industry. They have two options.

First, policy makers can design national allocation plans to avoid competitiveness issues – effectively moving from price internalisation to product internalisation. Thus product prices would not reflect $CO_2$ externality costs, and emission reductions from consumers and industry choosing less $CO_2$ intensive products are forgone.[13]

Second, policy makers can use the flexibility of the WTO framework to create a level playing field. For example, a border tax adjustment could reimburse exports from a region with price internalisation. Imports into the region face a tariff at the same level. If the level is set at the costs of $CO_2$ emissions faced by the best available

[13] Only few studies explicitly disentangle how much of $CO_2$ emission reductions can be expected from substitution and energy efficiency effects relative to fuel shifts and various low Carbon energy technologies. Vuuren (2004) attributes about 50% and Akimoto (2004) about 39% of CO2 emission reductions by 2050 that are induced by climate policy to energy efficiency. Yamaji et al. (2000) attribute an average of 25% of total emissions reductions to demand reductions. Averaging over the scenarios in Riahi (2004) only 14% of emission reductions are attributed to energy efficiency improvements, while most reductions attributed to Carbon Capture and sequestration and fuel shifting. The paper however also discusses the risk of exposure to these options and availability of resources.

technology, then the combination of $CO_2$ price-internalisation and border tax adjustment leaves industry outside the area covered by the scheme weakly better off than the absence of both schemes.[14] This should make the joint implementation WTO-compatible.

### 2.4 International support for national implementation

To support and facilitate national polices for $CO_2$ emission reductions, a variety of international co-operation initiatives have been proposed[15]. They have some or all of the following five objectives:

1) To offer a quid pro quo – countries pursue more stringent policies if they expect that this will either induce other countries to follow or if they mutually sign up for stringent policies.[16]
2) To minimise concerns over competitiveness issues and emission spill-overs which constrain and limit the efficacy of unilateral implementation of economic policies.
3) To reinforce commitment to the future national and regional policies in order to reduce uncertainty over the policy climate and attract private sector investment into clean technology, thereby reducing the cost of emissions abatement.[17]
4) To target the least-cost emission reduction opportunities through a globally equalised $CO_2$ price.
5) To engage developing countries.

The Kyoto process aims to implement all five objectives simultaneously. Perhaps national and regional implementation and international negotiations could be simplified if initially the fourth objective is dropped and global $CO_2$ trading is postponed.

[14] Careful design of Border Tax adjustment seems to be important (Ismer and Neuhoff 2004) and (Biermann and Brohm 2003) to reduce the risk of WTO incompatibility (Esty 1994) and minimise administrative requirements (Zhang 1998). If border tax adjustment is not implemented jointly with price internalisation, then justification seems to be more difficult (Charnovitz 2004). Demailly and Quirien (2006) illustrate for the cement sector the effectiveness of Border Tax Adjustment at the level of Best Available Technology.
[15] E.g. (Bodansky et al. 2004)
[16] See (Ashton and Wang 2004).
[17] (Bodansky 2004) argues that commitment "provides a signal to the market that helps drive changes in private behavior."

Global $CO_2$ trading received much attention, [18] perhaps because the benefits of targeting the least-cost abatement option can be readily quantified in models.[19] Some drawbacks are now emerging: First, potential exposure to large international financial transfers from international emissions trading complicate international negotiations about future climate commitments. Domestic constituencies might be more willing to share environmental objectives than to accept financial liabilities. Second, the least ambitious country might limit the global $CO_2$ price to a lowest common denominator. Third, global $CO_2$ trading requires far reaching harmonisation of national policies – which could be difficult to negotiate and might reduce domestic political support.

## 2.5 Future objectives for international co-ordination

International negotiations could focus on the first three objectives and define stringent national emission targets.[20] Within these targets, countries could continue to choose the policy mix they consider most suitable for their circumstances. This allows for a parallel evolution of national policies.

National or regional policy makers can thus retain more flexibility in the choice and implementation of policy instruments. They might still want to coordinate on one aspect – to use instruments that reflect $CO_2$ externality costs in product prices. Countries could then choose whether they want to use $CO_2$ taxes or an emission-trading scheme that implements price internalisation. This would address the competitiveness aspects and emission spill over which would result if some countries were to only implement production internalisation. The relative price increases for energy and energy intensive products offers the additional benefit of reducing national energy demand, thus addressing another political concern: that of security of supply.[21]

Quantification of targets facilitates monitoring and makes a commitment by national governments more credible.[22] Whether to define long-term targets in absolute terms or relative to GDP intensity is widely debated, and there are good arguments for

[18] Philibert and Reinaud. argue that “emission trading might be the centerpiece for international efforts to build a global and comprehensive greenhouse gas mitigation regime” (2004). “[A globally integrated trading scheme] creates a larger, more liquid market and so should generate bigger cost savings.”(Bell and Drexhage 2005). Aldy et al. (2004) argue “with more countries participating, emission allowance prices would be subject to less uncertainty and variability.”

[19]Webster et al. (2006) investigate the value of international emissions trading and argue that the benefits calculated for international emission trading stem largely from the burden redistribution effect. The negative impact of emission trading on the balance of payments could outweigh the benefits from hedging and identifying least cost abatement options.

[20] Pershing and Tudela (2004) discuss the appropriate formulation of such a targets, e.g. as global temperature increase, as $CO_2$ concentration or as $CO_2$ emission. Defining targets that are most sensitive to human activity (e.g. annual emissions) avoids uncertainty that results if the impact of human activity on more indirect systems has to be analysed (like CO2 concentration or global temperature). Reducing uncertainties then reduces “opportunities for discord and delay”.

[21] (Edenhofer and Lessmann 2005)

[22] For the value of government commitment to environmental policy see Helm et al. (2003).

both sides.[23] Both approaches can probably exist in parallel. Translating long-term GDP intensity-based targets into absolute targets before the relevant year is likely to increase transparency and credibility, and facilitates the implementation of price internalisation.

Definition of emission reduction milestones in addition to the long-term target seems desirable. In the absence of clearly defined milestones, policy-makers delay tough decisions on climate policy. This seems to be more of a risk then the drawback of milestones: Milestones reduce intertemporal flexibility and could thus prevent governments from optimally timing climate policy. Macro-economic models show that this could increase costs.

Unexpected events can create emission levels that exceed the national targets. This requires both flexibility to respond to unexpected events and incentives to ensure governments and industry do not abuse the flexibility. The Clean Development Mechanism allows countries and companies to invest in projects to compensate their excess emissions. Flexibility to cover shortfalls could be created if some of future emission reductions projected for a project can be credited. [24] Incentives to achieve national targets could be increased, if an exchange rate or a tax is introduced for CDM project credits relative to domestic emission reductions.

## 2.6 Engaging developing countries

Developing countries have limited responsibility for historic emissions, just as they have a lower capability to finance emission reductions.

During the Kyoto negotiations, therefore, only developed countries took on stringent targets. The Clean Development Mechanism then aimed to realise some of the potential for emission reductions in developing countries based on funding and technology transfer from developed countries.[25]

However, it is worth noting that, by 2010, developing countries are expected to contribute 39% of global $CO_2$ emissions. Stabilisation of $CO_2$ concentration is thus difficult without the participation of developing countries.[26] Furthermore, according

[23] Intensity based targets create in some circumstances more predictability. Absolute targets offer more transparency and beneficial counter-cyclical properties (Wing et al. 2006). Ellerman and Sue Wing (2003) suggest that emission targets might increase less than one to one with GDP increase. Bodansky (2004) argues that “indexed or conditional targets ... are compatible with the architecture established by Kyoto, ... but are more flexible ... than absolute targets ... and thus could credibly be characterized as a different approach from Kyoto.”
[24] To ensure that investments could contribute to investment in new energy technologies, World Bank (2006) argues that subsequent revenue streams would need to be collateralized.
[25] Michaelowa, Butzengeiger and Jung (2005)
[26] World Energy Outlook (IEA 2005)

to the IEA, in the next 24 years, 50% of global energy sector investment will be located in developing countries. [27] Without appropriate policies, inefficient investment will increase the cost of subsequent emissions reductions. Finally, the close link between climate and energy policy also suggests that developing countries can benefit if for example climate policy increases energy efficiency and reduces energy import dependency.[28]

This opens the big question: how to encourage developing countries to implement stringent climate policies?[29]

Some have envisaged developing countries receiving $CO_2$ emission budgets above their expected emissions. Sales revenue from excess credits would provide an incentive for them to implement national policies.[30] However, the reluctance of European countries, Canada and Japan to buy such credits from, for example, the Russian government, suggests that this is no longer a credible approach.

Expanding the CDM framework to cover sets of projects or entire sectors[31] would effectively scale up the project-based approach. However, with a scaling up of size, the costs will also scale up. In addition, over time the choice of counterfactuals becomes more complex. Counterfactuals (or base lines) are required to define how much emission reductions can be attributed to a project. Continued micro-management distorts the markets and the lack of policies that implement proper price-internalisation prevents emission reductions from encouraging substitution.

Sectoral agreements could cover a specific sector at a global scale, including developing countries.[32] Focus on $CO_2$ intensive sectors is argued to reduce complexity and might increase political acceptability. Current activities by industry focus on reporting and envisage some commitment to phase out technologies with

---

[27] World Energy Outlook (IEA 2005)

[28] Heller and Shukla (2004) argue “For some time to come developing countries emissions will continue to be derivatives of other development choices, and can be better managed if recognized as such.” They suggest a way beyond the present difficulties of North-South collaboration would be to seek climate-favouring activities that emerge as ancillary benefits of sound development programs. However, development and climate change objectives are not necessarily aligned. Pan et al (2005) illustrate at the Chinese example how increasing living standards is expected to increase energy demand and $CO_2$ emissions.

[29] Heller and Shukla (2004) conclude: “Integrating climate and development objectives calls for a new political bargain with new political actors to redefine collective responsibilities to address climate change.”

[30] Shiell shows in a formal model that the resulting more stringent targets can represent a Pareto improvement (2003).

[31] Samaniego and Figueres (2002) discuss the extension of CDM to sectoral CDM in order to cover a wider range of projects. Drawig on work by Philibert and Pershing (2001) they argue that “S-CDM does not operate as a *sectoral target*”, they also discuss the option that an “internal clearinghouse mechanism could discover the average reduction cost over the whole [sectoral CDM] project.” In this interpretation S-CDM could be used to compensate a national/regional government or a sector for the real cost incurred for the implementation of stringent emission policy. Note that the real cost incurred are typically a fraction of price changes induced by emission trading.

[32] See for example Bosi and Ellis (2005).

high emissions. Thus they could initiate an engagement of a wider set of countries and target low cost emission reductions.[33] Yet without government involvement, these sectoral agreements are unlikely to evolve to stringent $CO_2$ price internalisation policies,[34] which would address competitiveness issues and emission spill-over.

New strategies are needed, strategies which are tailored according to capabilities and needs of different developing countries, to encourage the implementation of stringent $CO_2$ policies with price internalisation.[35]

## 3. Technology policy

### 3.1 Basic principles

Private investment in research is difficult to protect with patents other than in special sectors like pharmaceuticals. As a result, private-sector companies do not capture the full benefit of their investment[36] and are likely to under-invest in research.[37] Therefore, public funding and tax breaks are frequently used to fund public research and to support private-sector research.

New energy technologies face an additional challenge: they compete against established technologies with decades of experience, during which the technology and production process have been improved and costs have been reduced.[38]

---

[33] Sectoral agreements if linked with sectoral targets allow participation of developing countries without requiring that they have to take on targets for the whole economy (Tangen and Hasselknippe 2005). They could also be used in parallel with national policy instruments.

[34] Philibert (2004) finds "limited evidence as to ...environmental effectiveness [of voluntary approaches]." But "they are likely to generate significant "soft effects" – for example, sharing information on best practice and raising awareness of emission and energy use ... [and] be a useful first step to stricter mandate requirements." Watson et al. (2005) argue that free rider issues of voluntary agreements are easier to address among few players in concentrated sectors, but for example in China both Steel and Cement are produced by many 'small' firms.
An extension of Clean Development Mechanisms might be used to provide funding to convince industry and developing countries to implement legally binding sectoral agreements with stringent emission targets.
World Bank (2006) also concludes that "Voluntary actions, while important, are unlikely to fill the gap [in moving towards low Carbon economic structures]."

[35] Winkler et al (2006) suggest approaches to differentiate among non-Annex I countries for future mitigation commitments. Michaelowa et al (2005) suggest that developing countries that exceed a thresh-hold, defined by GDP per capita and emissions, graduate to become responsible for mitigation efforts.

[36] Margolis and Kammen (1999) estimate that private returns on R&D across various sectors are between 20-30% while social rates of return are around 50%.

[37] Lev (2004) observed among companies that are members of the industrial research institute that they reduced the allocation of R&D funds to basic research every year from 1993 to 2003, in favour of modifications and extensions of current products.

[38] Arthur (1989)

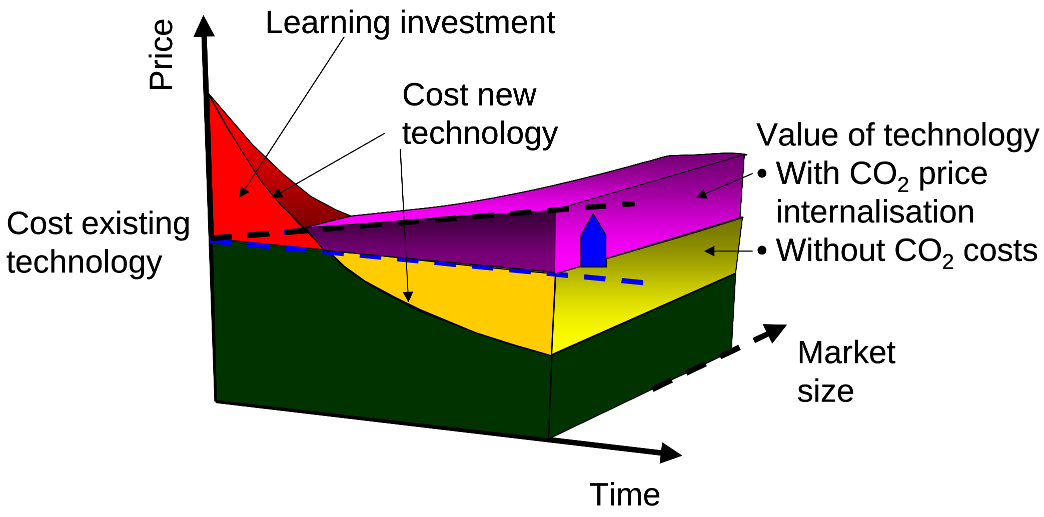


*Figure 2 Experience curve for energy technologies competing with homogeneous product*

Figure 2 illustrates how costs of new energy technologies are expected to fall with increasing production experience and complementing research efforts.[39] For this to work, growing markets are required to attract investment in new production facilities. In the automotive or telecom sectors, product differentiation creates these new markets and allows companies to charge a premium over existing products. This does not work for energy, as it is an almost homogeneous product.

In the pharmaceutical sector, large up-front investments are financed through future revenues in markets which are protected by patents This approach is not viable for energy technologies, as engineering patents are difficult to protect, and input from many companies is required to advance a new energy technology.[40]

Strategic deployment can create markets for new energy technologies based on feed-in tariffs or renewable quotas.[41] Electricity consumers pay the premium that is required to use new energy technologies. If the premium is differentiated for different technologies according to their level of development, then a portfolio of new energy technologies can thus be developed. This creates the option to use energy technologies according to demand structure, cost requirements and renewable resource potential.

### 3.2 Experience with technology policy

[39] International Energy Agency (2000)
[40] See Neuhoff (2005) for more detailed discussion and Irwin and Klenow (1994) for the example of the semiconductor industry.
[41] Butler L., Neuhoff K (2005).

Public R&D support for energy technologies in IEA countries has fallen over recent decades from USD 35billion in 1980 to USD 9.4billion in 2004, measured in 2004$. In these IEA countries, 50% of the funding is allocated to fission and fusion, 12.3% to fossil fuels and 7.7% to renewable energy technologies.[42]

Strategic deployment policies for renewable energy sources like wind and solar photovoltaics have succeeded in pushing down prices. These strategic deployment policies offer the advantage of a clearly defined market interface between public decision-makers and the private sector. This provides robust information about the progress of a technology and thus allows governments to abandon support of unsuccessful technologies. Strategic deployment programmes also allow technology companies to make profits, which they can reinvest in R&D. [43] Such private sector R&D investment is a credible signal to government that can be used to target public sector R&D support.

### 2.3. Technology policy in a multilateral world

The primary objective of support programmes for low-carbon technologies are global emission reductions and lower rates of depletion of fossil fuels. Technology spill-over is required to achieve these objectives and is therefore less of a concern than for technology policies in other sectors.

National support programmes are also motivated by the expectation that such programmes will create a first-mover advantage for national industries in a global market. Further growth and cost reductions of technologies like photovoltaics require implementation of strategic deployment by additional countries. These countries benefit from the development of complementing institutions and infrastructure but might not necessarily develop a national manufacturing base.

### 3.4 International measures to support national implementation

Funding for R&D and demonstration projects is usually targeted at national industries. For established technologies, national industries seem to succeed in mobilising public funds. To increase R&D and demonstration funding for technologies with a less-established constituency, some international co-ordination might be helpful – a quid pro quo to internalise the benefits of technology spill-over.

With strategic deployment, it is competitive markets rather than policy-makers, which identify the best approach to produce for example photovoltaics. Competitive markets are open for foreign companies, to ensure that the best

[42] Averaged over the period 1987-2002, IEA (2004)
[43] Jensen (2004) provides a case study for wind energy.

technological solutions are pursued. This reduces support for such programmes from the national industrial constituency. Therefore, more international co-ordination will be required to support strategic deployment programmes.

With more countries implementing strategic deployment programmes, global demand will be less affected by changes of national policies. This stabilised demand, reduces the risks for technology producer, and allows them to increase investment in R&D and exploration of new production processes, thus accelerating technology improvements.

Developing countries have some of the best renewable resources and various high-value applications, due to their decentralised demand. Perhaps making the various policy objectives of energy projects in developing countries more explicit would allow for a better use of these opportunities. This could involve a clear labelling of what component of a funding package is motivated by development objectives, $CO_2$ emission reductions and strategic deployment of a new energy technology.[44]

Transfer of energy technologies, including patents and tacit firm knowledge, could allow for leveraging of lower production costs in developing countries. It has to be carefully structured to ensure that technology companies retain incentives for further technology development.

## 4. Non-marketplace barriers

### 4.1 Basic principles

Energy-intensive industries directly react to energy and $CO_2$ price signals. Other industrial sectors and private consumers are less responsive, as energy costs only constitute a small part of their total costs. Therefore they do not acquire the necessary information about the implications of their choices, do not adjust their habits and established protocols, and do not investigate profitable investment opportunities for energy-efficiency improvements.

Historically developed institutional arrangements can also constitute barriers, as two examples illustrate. First, landlords might not invest sufficiently in insulation and heating devices if they do not benefit from the energy savings, which their tenants enjoy.[45] Second, electricity market designs are tailored for historic generation

---

[44] This should also allow addressing in parallel “competing needs of resources from other development needs.” World Bank (2006). However, current funding for such targeted efforts, for example funding of the Global Environmental Facility, is rather limited (about $150 mio. per year).

[45] Sorrell and Sijm discuss the interaction of Carbon trading and policies to promote energy efficiency (2003).

technologies and can create unnecessary costs for the integration of some renewable energy technologies.[46]

### 4.2 Experience with non-marketplace barriers

National and regional governments have implemented various programmes to address non-marketplace barriers.[47] The programmes range from information provision to outright banning of some inefficient devices.[48] They are usually tailored for the specific needs of societies and cultural backgrounds. While some of these policies seem to have been successful, many studies suggest that large amounts of cost-effective $CO_2$ emissions-reduction opportunities remain. One reason that policies have not yet addressed this latent potential could be that governments have not set quantitative targets for policies that address non-marketplace barriers. It is, after all, difficult to define a metric classifying the level of barriers. However, this limits governments' opportunity to benchmark: to measure the success of these policies and improve their management.

### 4.3 Non-marketplace barriers in a multilateral world

National emission reduction targets, whether formulated unilaterally or – more credibly– in an international context, also measure the success of policies in removing non-marketplace barriers. Quantification allows tracking, monitoring and therefore better management of success. The interests of government, industry and civil society are aligned on the success of such policies, as these policies offer low-cost opportunities for emission reductions.

Removal of non-marketplace barriers within countries should be beneficial for the economy and thus not create competitive disadvantages. Thus international co-ordination is less important. However, careful design is required to ensure policies such as product labelling or minimum efficiency standards are WTO-compatible. International co-ordination of such policies could facilitate political acceptance and reduce administrative and enforcement costs.[49]

---

[46] (Unruh 2000) Higher efficiency technologies / renewable technologies are also more exposed to regulatory risk. World Bank (2006) argues that the "existing risk management product base has to be expanded to provide for ... higher efficiency energy and infrastructure development. See also Duke and Kammen (1999).

[47] A detailed discussion can be found in Chapter Five of 'Barriers, Opportunities, and Market Potential of Technologies and Practices' (IPCC 2001).

[48] See for example (Hassett and Metcalf 1993) for a discussion whether consumers do make rational decisions. Policies to address non market based barriers like labelling or efficiency standards need to be carefully designed to not ensure WTO compatibility (Charnovitz 2004).

[49] Barrett (2003) suggests that "If enough countries adopt a [technology] standard, it may become irresistible for others to follow, whether because of network effects, cost considerations ... or lock in."

## 5. Conclusion

Stabilising atmospheric $CO_2$ concentration at tolerable levels requires large reductions of $CO_2$ emissions, but macroeconomic models suggest that costs will be limited if an optimal policy mix allows the economy to make an effective and forward-looking response.

The challenge for climate policy-makers, therefore, is to find and effectively use policies to internalise $CO_2$ externalities, advance new technologies and address barriers. The focus on all three dimensions is on national and regional implementation.

International co-ordination can support national implementation. The motivation for countries to commit to and pursue stringent targets increases if they jointly commit to these targets. Outside commitment also increases the credibility of national targets in facilitating national implementation and they provide a metric to measure and manage the success of policies. Thus co-operation on climate policy can help national governments in their task of addressing energy-policy challenges such as security of supply or energy import dependency.

National and regional governments are usually well-positioned to implement these policies. They retain flexibility to choose from a menu of instruments the most suitable approach for their circumstances. To address competitiveness effects and emission spill-over, countries can agree to use instruments that result in price internalisation and thus reflect the $CO_2$ costs in product prices.

## References


Akimoto, K., T. Tomoda, Y. Fujii and K. Yamaji (2004) Assessment of global warming mitigation options with integrated assessment model DNE21. *Energy Economics* 26(4): P.709-719.

Aldy, J. E., R. Baron and L. Tubiana (2004) Addressing Cost: The Political Economy of Climate Change. *Beyond Kyoto: Advancing the international effort against climate change*, PEW Center on Global Climate Change.

Arthur, W. B. (1989) Competing Technologies, Increasing Returns, and Lock-In by Historical Events. *The Economic Journal* 99(394): P.116-131.

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

Barrett, S. (2003) *Environment and Statecraft*. Oxford, Oxford University Press.

Bell, W. and J. Drexhage (2005) Climate Change and the International Carbon Market.

Biermann, F. and R. Brohm (2003) Implementing the Kyoto Protocol without the United States: The Strategic Role of Energy Tax Adjustments at the Border.

Bodansky, D. (2004) Climate Commitments: Assessing the Options. *Beyond Kyoto: Advancing the international effort against climate change*, PEW Center on Global Climate Change.

Bodansky, D., S. Cou and C. Jorge-Tresolini (2004) International Climate Efforts Beyonod 2012: A Survey of Approaches. *Advancing The International Effort Against Climate Change*, Pew Center on Global Climate Change.

Butler, L. and K. Neuhoff (2005) Comparison of Feed in Tariff, Quota and Auction Mechanisms to Support Wind Power Development.

Charnovitz, S. (2004) Trade and Climate: Potential Conflicts and Synergies. *Beyond Kyoto: Advancing the international effort against climate change*, PEW Center on Global Climate Change.

Demailly, D. and P. Quirion (2006) Leakage from climate policies and border tax adjustment: lessons from a geographic model of the cement industry.

Duke, R. and D. M. Kammen (1999) The Economics of Energy Market Transformation Programs. *The Energy Journal* 20(4): P.15-64.

Edenhofer, O., K. Lessman, C. Kemfert, M. Grubb and J. Köhler (2006) Induced Technological Change: Exploring its Implications for the Economics of Atmospheric Stabilization. *Energy Journal*(Special Issue: Endogenous Technological Change and the Economics of Atmospheric Stabilization): P.57-122.

Edenhofer, O. and K. Lessmann (2005) Climate Policy and Energy Security. *Options for Future Climate Policy: Transatlantic Perspectives*. F. Muller and A. Riechel. Berlin, German Institute for International and Security Affairs**:** 111-123.

Ellerman, A. D. and I. S. Wing (2003) Absolute versus intensity-based emission caps. *Climate Policy* Special Issue(S2): P.S7-S20.

Ellis, J. and M. Bosi (2005) Exploring Options for "Sectoral Crediting Mechanisms". *OECD Environment Directorate, IEA*. Paris, OECD/IEA.

Esty, D. C. (1994) *Greening the GATT - Trade, Environment and the Future*. Washington/D.C, Institute for International Economics.

EU Council of  Ministers for the Environment (2006) PRESS RELEASE: 2713th Council Meeting Environment. P. M. J. PRÖLL. Brussels.

Fischer, C. and R. Morgenstern (2003) Carbon Abatement Costs:  Why the Wide Range of Estimates. Washington, RFF.

Hassett, K. A. and G. E. Metcalf (1993) Energy conservation investment: Do consumers discount the future correctly? *Energy Policy* 21(6): P.710-716

Heerden, J. v., R. Gerlagh, J. Blignaut, M. Horridge, S. Hess, R. Mabugu and M. Mabugu (2006) Searching for Triple Dividends in South Africa: Fighting CO2 Pollution and Poverty while Promoting Growth. *Energy Journal* 27(2).

Heller, T. C. and P. R. Shukla (2004). Development and Climate: Engaging Developing Countries. *Beyond Kyoto: Advancing the international effort against climate change*, PEW Center on Global Climate Change.

Helm, D., C. Hepburn and R. Mash (2003) Credible Carbon Policy. *Oxford Review of Economic Policy* 19(3): P.438-450.

IEA (2000) Experience Curves for Technology Policy. *International Energy Agency*(Paris).

IEA (2004) Energy Technology R&D Statistics Database, IEA.

IEA (2005) World Energy Outlook 2005: Middle East and North Africa Insights. *World Energy Outlook*. I. E. Association. Paris, IEA.

IPCC (2001) *IPCC Third Assessment Report 2001*.

Irwin, D. and P. Klenow (1994) Learning-by-doing spillovers in the semiconductor industry. *Journal of Political Economy* 102: P.1200-1227.

Ismer, R. and K. Neuhoff (2004) Border tax adjustments : a feasible way to address nonparticipation in emission trading. *Cambridge working papers in economics; CWPE 0409*. Cambridge, CMI Electricity Project Department of Applied Economics.

Jensen, S. G. (2004) Reducing costs of emerging renewable energy technologies - an analysis of the dynamic development with wind power as case study. *International Journal of Energy Technology and Policy* 2(1/2): P.179-202.

Kainuma, M., Y. Matsuoka, T. Morita, T. Masui and K. Takahashi (2004) Analysis of global warming stabilization scenarios: the Asia-Pacific Integrated Model. *Energy Economics* 26: P.709-719.

Lev, B. (2004) Sharpening the Intangibles' Edge. *Harvard Business Review* June 2004: P.109-116.

Margolis, R. M. and D. M. Kammen (1999) Evidence of under-investment in energy R&D in the United States and the impact of Federal policy. *Energy Policy* 27(575-584).

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

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

Mori, S. and T. Saito (2004) Potentials of hydrogen and nuclear towards global warming mitigation-expansion of an integrated assessment model MARIA and simulations. *Energy Economics* 26(4): P.565-578.

Neuhoff, K. (2005) Large-Scale Deployment of Renewables for Electricity Generation. *Oxford Review of Economic Policy* 21(1): P.88-110.

Neuhoff, K., K. Keats and M. Sato (2006) Allocation, incentives and distortions: the impact of EU ETS emissions allowance allocations to the electricity sector. *Climate Policy*(Special Issue: Emissions allocation, incentives and industrial competitiveness under the EU Emissions Trading Scheme, forthcoming).

Newbery, D. M. (2003) Sectoral dimensions of sustainable development: energy and transport. *Economic Survey of Europe* 2(73-93).

Newell, R., W. Pizer and J. Zhang (2005) Managing Permit Markets to Stabilize Prices. *Environmental and Resource Economics* 31(2): P.133 - 157.

Pan, J., X. Zhu and Y. Chen (2005) Fulfilling basic development needs with low emissions: China's challenges and opportunities for building a post-2012 climate regime. *Governing Climate: The Struggle for a Global Framework beyond Kyoto*: P.89-108.

Pershing, J. and F. Tudela (2004) A Long-Term Target: Framing the Climate Effort. *Beyond Kyoto: Advancing the international effort against climate change,* PEW Center on Global Climate Change.

Philibert, C. (2004) Technology Innovation, Development and Diffusion. *OECD and IEA Information Paper,* COM/ENV/EPOC/IEA/SLT.

Philibert, C. and J. Pershing (2001) Considering the Options: Climate Targets for All Countries. *Climate Policy* 1: P.211-227.

Philibert, C. and J. Reinaud (2004) Emissions trading: taking stock and looking forward, *COM/ENV/EPOC/IEA/SLT*, OECD/IEA.

Pizer, W. (2002) Combining price and quantity controls to mitigate global climate change. *Journal of Public Economics* 85(3): P.409-434(26).

Riahi, K., E. S. Rubin, M. R. Taylor, L. Schrattenholzer and D. Hounshell (2004) Technology learning for carbon capture and sequestration technologies. *Energy Economics*(26): P.539-564.

Samaniego, J. and C. Figueres (2002) Evolving to a Sector Based Clean Development Mechanism. *Options for protecting the climate*. K. Baumert. Washington, DC, World Resource Institute.

Shiell, L. (2003) Equity and efficiency in international markets for pollution permits. *Journal of Environmental Economics and Management* 46: P.38-51.

Smith, S. and J. Swierzbinki (2006) The UK Emissions Trading Scheme.

Sorrell, S. and J. Sijm (2003) Carbon Trading In The Policy Mix. *Oxford Review of Economic Policy* 19(3): P.420-437.

Tangen, K. and H. Hasselknippe (2005) Converging Markets. *International Environmental Agreements: Politics, Law and Economics* 5(1): P.47 - 64 .

Unruh, G. (2000) Understanding carbon lock-in. *Energy Policy* 28(28): P.817-830.

Van Vuuren, D. P., d. V. B., B. Eickhout and T. Kram (2004) Responses to technology and taxes in a simulated world. *Energy Economics* 26: P.579-601.

Watson, C., J. Newman, R. Upton and P. Hackmann (2005) Can Transnational sectoral agreements help reduce Greenhouse Gas Emissions? *Round Table on Sustainable Development*. Paris, OECD.

Webster, M., S. Paltsev and J. Reilly (2006) The Value of Emissions Trading. *MIT Joint Program on the Science and Policy of Global Change*.

Weitzman, M. L. (1974) Prices vs. Quantities. *Review of Economic Studies*(41(4)): P.477-491.

Wing, I. S., A. D. Ellerman and J. Song (2006) Absolute vs. Intensity Limits for $CO_2$ Emission Control: Performance Under Uncertainty. *MIT Joint Program on the Science and Policy of Global Change*, MIT.

Winkler, H., B. Brouns and S. Kartha (2006) Future mitigation commitments: differentiating among non-Annex I countries. *Climate Policy* 5(5): P.469-486.

World Bank (2006) Clean Energy and Development: Towards an Investment Framework. *Environmentally and Socially Sustainable Development Vice Presidency*, World Bank.

Yamaji, K., J. Fujino and K. Osada (2000) Global energy system to maintain atmospheric CO2 concentration at 550ppm. *Environmental Economics and Policy Studies* 3(2): P.159.

Zhang, Z. X. (1998) Greenhouse Gas Emissions Trading and the World Trading System. *Journal of World Trade* 32(5): P.219-239.