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EMISSIONS TRADING:
TAKING STOCK AND LOOKING FORWARD

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FOREWORD

This document was prepared by the OECD and IEA Secretariats at the request of the Annex I Expert Group on the United Nations Framework Convention on Climate Change. The Annex I Expert Group oversees development of analytical papers for the purpose of providing useful and timely input to the climate change negotiations. These papers may also be useful to national policy makers and other decision-makers. In a collaborative effort, authors work with the Annex I Expert Group to develop these papers. However, the papers do not necessarily represent the views of the OECD or the IEA, nor are they intended to prejudge the views of countries participating in the Annex I Expert Group. Rather, they are Secretariat information papers intended to inform Member countries, as well as the UNFCCC audience.

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC (as amended at the 3rd Conference of the Parties in December 1997): Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom of Great Britain and Northern Ireland, and United States of America. Korea and Mexico, as new OECD member countries, also participate in the Annex I Expert Group. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations", if appropriate.

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EXECUTIVE SUMMARY

Tradable permit schemes have been successfully used in many applications for protecting the environment or limiting access to natural resources. In particular, emissions trading has been used in several applications with air pollutants.

Emissions trading has been considered a possible tool for mitigating greenhouse gas emissions since the early 90s and became part of the Kyoto Protocol agreement. Although the Protocol has not yet entered into force, there are a great number of initiatives that aim at instituting emissions trading for greenhouse gas sources, at various levels: national, state, local and corporate. Generally, such schemes are designed to provide information and experience to companies and governmental agencies by practical experience of trading carbon dioxide equivalent emissions.

The lessons learnt in the last two decades from both practical experiences of tradable permit schemes and continuous analytical efforts, depict emissions trading not as a goal by itself, but as a tool to achieve environmental goals most cost-effectively. However, cost-effectiveness can only be achieved if the market is sufficiently liquid and is effective. This proven cost-effectiveness of trading regimes has not prevented the occurrence of price spikes which can in turn reduce the environmental effectiveness of the scheme. Moreover, the design of a trading scheme should consider several features in order to enhance the achievement of the environmental objective and facilitate the efficient operation of a competitive and cost effective market. Such elements include allocation mode (upstream versus downstream and grandfathering versus auctioning), coverage of the regime, compliance systems, and issues such as banking and borrowing.

Environmental effectiveness should be seen in a dynamic perspective: as emissions trading reduces compliance costs, it should allow fixing more ambitious environmental objectives than could be achieved with “command-and-control” regulations.

Looking into the future, emissions trading might be the centrepiece of international efforts to build a global and comprehensive greenhouse gas mitigation regime. Cost-effectiveness is a common feature of both emissions trading and taxes. But taxes make all sources pay for all their emissions, while emissions trading gives governments a great deal of flexibility between auctioning and free allocation. Moreover, emissions trading allows negotiators to focus on an acceptable allocation of efforts – or allocation of allowances – while taxes do not.

The main issue that still needs to be dealt with is cost uncertainty. Abatement costs are and will remain largely uncertain and fixed and binding targets entail unpredictable costs. Indeed, they provide certainty on emission levels (assuming full compliance) - but this short-term environmental certainty is of little value in the context of a global, long term and cumulative pollution externality.

Allowing some more flexibility in each year’s emission levels would reduce expected costs and facilitate the adoption of relatively more ambitious policies then otherwise.

Parties may wish to consider several options to increase flexibility in face of uncertain costs - either new options for countries’ quantified objectives or additional mechanisms:

- Time flexibility through banking and borrowing could be one of these – but borrowing raises concerns in international agreements with weak compliance regimes;

- Dynamic targets – an option for both industrialised and developing countries – would adjust allowances to actual economic growth and reduce uncertainty arising from unexpected deviations from economic forecasts – but not uncertainty from future technology developments;

- Price caps – the possibility for governments or an international body to sell supplementary permits at a fixed price – would reduce cost uncertainty, avoid price-spike problems and help countries adopt more ambitious policies;

- Non-binding targets would allow some countries to sell possible surplus allowances but would not require them to cover possible deficit by buying allowances from others. A trading regime could not work if this option were extended to all participants; it must be reserved to some of them, presumably (some) developing countries;

- Sector-wide targets that could be binding or non-binding, dynamic or fixed, could offer a pragmatic first step for countries willing to participate and gain experience.

These options are complementary rather than exclusive. They could be simultaneously implemented, with different countries selecting different policies according to their national circumstances. This would acknowledge a main lesson from the Kyoto process – the fact that countries around the world differ widely and may need different forms of commitments. It may also emerge that some of these options are most useful as a transitional stage to more comprehensive forms of agreements. Finally, a global emissions trading system might be either implemented as a result of a global agreement or by the progressive linking of several regimes instituted at other levels.

1. INTRODUCTION

Emissions trading or, more generally, tradable permit systems, have already been used to deal with various environmental or resource problems since the 1970s, notably air pollution, fisheries, water management, waste management and land-use. Emissions trading has been considered as a possible tool for mitigating greenhouse gas emissions since the early 1990s.

Emissions trading between countries became part of the 1997 Kyoto Protocol. Operating rules were agreed at COP7 (2001) in Marrakech. And, although the Protocol has not yet entered into force, there are a great number of initiatives that aim at instituting emissions trading for greenhouse gas sources, at various levels. GHG emission trading systems now exist in a wide range of forms, with systems covering individual countries or groups of countries (e.g. the European Union) to large multinational companies such as Shell and BP to various states or local authorities in various countries.

Meanwhile, the prospect of the creation of the first ever international market for emission allowances has stimulated intellectual work in the field. Analysts throughout the world, from academics, government, companies as well as international organisations, have intensively studied and debated many related issues, notably coverage, allocation, liability, banking and borrowing, insertion in policy mix, competitiveness, impacts on investments, linkages between domestic systems, comparisons with other economic instruments and the like. Analyses are developed from both theoretical perspectives and from practical experience.

While concrete experience on actual greenhouse gas emissions trading at both international and domestic levels remains in its infancy, it may not be too early to "take stock" of the progress made on all these fronts, to identify the first lessons that might be drawn from both actual experience and recent analytical work, and consider what role emissions trading could play as a tool to support greenhouse gas mitigation action in the future. This is the purpose of this paper.

The paper begins with a descriptive part, "stock taking", where it reviews the existing experiences in various fields, including the current build-up of greenhouse gas regimes. Its next section is an analysis of the "lessons learned". It reviews evidence about emissions trading, then reviews current thinking about the most important design issues, notably with respect to domestic regimes. The last part of the paper considers what future role emissions trading could play in tackling climate change. It looks at how future regimes might deal with the uncertainties surrounding climate change and, in particular, abatement costs over a century timescale. It also suggests there are ways and options for creating a global regime that could benefit all participating countries and effectively tackle climate change.

It is the cap in a cap-and-trade scheme (or equivalently the baseline in a baseline-and-credit scheme) that mostly creates the environmental benefit The cap on its own would produce the same environmental effect – the trading component only helps to achieve the cap more cost-effectively (albeit with some dynamic implications for the stringency of caps that might be undertaken).

Emissions trading is not a goal by itself, only a tool. Najam et al (2003), in a presentation of "developing countries concerns and interests" in the climate negotiations beyond Kyoto, noted: *"There is a danger that Kyoto has now become so much of a mechanism for managing global carbon trade that the issue of emission cuts for atmospheric carbon stabilisation could be neglected, or at least delayed"*.

Nevertheless, this paper suggests that emissions trading offers a major opportunity to help achieve the ultimate objective of the UNFCC Convention. Emissions trading systems that are both environmentally effective and cost-effective also offer an important policy advantage by allowing for acceptable negotiated outcomes at a global level. However, they need some refinements to better deal with the deep and long-lasting uncertainties on abatement costs and technology developments over a century or more and the policy concerns these uncertainties raise.

2. TAKING STOCK

This section traces the origins of tradable permit schemes to protect the environment or natural resources. It then summarises the various attempts to implement emissions trading to deal with air pollutants, and takes stock of the recent and on-going attempts to introduce greenhouse gas emissions trading at various levels. It finally discusses emissions trading in policy mixes.

2.1 Origins of Emissions Trading

Economists spend much of their time attempting to understand how markets work. In the case of tradable permit schemes, the reverse is true: these markets have been created from theoretical considerations. Their origins are usually traced back to a famous article by Ronald Coase (1960) – a sharp criticism of the "Pigouvian[1] tradition" that gave birth to environmental taxes. This led J.H. Dales (1968) to suggest introducing transferable pollution rights to deal with pollution externalities. Various economists further developed that concept or backed it by demonstrating that current command-and-control policies dealing with pollution or other environment or natural resources problems were needlessly costly and could be dealt with more cost-effectively with tradable permits. One important theoretical development was a series of papers in the 70s identifying the criteria that help choose either taxes or permit systems to maximise net expected benefits (expected climate benefits minus expected abatement costs) when abatement costs are not known with certainty.

Today, emissions trading is the name that tradable permit schemes take when applied to polluting emissions. Tradable permit schemes may also apply to fishing or hunting, to exploiting forests or lands, including by building settlements, or even to foster new technologies in specific areas. Put simply, tradable permits are also a more general concept that can be used to create markets of various types, not only to deal with environmental or natural resources issues.

Emissions trading is a broad concept covering "cap-and-trade" and "rate-based trading" regimes, and sometimes "project-based" mechanisms (see table 1 below for a comparison) that usually exist in relationship with one of the two former regimes. This paper focuses mostly on cap-and-trade and rate-based trading regimes.

Most tradable permit experiences link government regulations with markets. Permits delivered by governments to economic agents, most often firms, are recognised as a means of complying with a certain regulation. The permits are then simply recognised as tradable. In the case of polluting emissions, for example, firms are given allowances or permits to emit fixed (absolute) amounts of emissions over a given period of time. Firms that can cheaply reduce their emissions more than stipulated by the government regulation can offer to sell surplus emission rights to others that have only costlier options for reducing emissions. As a result, the total cost incurred by companies in achieving the environmental goal set by the government is lower than in case of pure "command-and-control" environmental regulation, as will be shown below – and this benefits the society as a whole.

In a few cases, tradable permit schemes have been created in the absence of immediate governmental intervention. However, it is unlikely that these few examples can be generalised. Most market actors will not take into account a carbon cost without any governmental intervention, not because they are "bad" but simply because competition hardly allows for such "good" behaviour. Thus, government intervention is needed at a country level, and for the same reason, a negotiated outcome is preferable at a global level than

[1] After the name of the famous economist A.C. Pigou who suggested in 1920 using taxes to internalise the cost of externalities in his book *The Economics of Welfare*. For a defence of the Pigouvian tradition, see Baumol, 1972.

a less likely unilateral action. But, contrary to many other government interventions, tradable permit schemes use the virtues of markets to reduce costs.

Table 1: **Allowance and credit schemes**

Cap-and-trade	**Rate-based Trading**	**Project-based credit**
Applies to all emissions	Applies to emission vis-à-vis some defined standard (e.g., emissions per unit of output)	Applies to emission *reductions* below defined baseline
All emissions can be traded	Emission above or below the standard can be traded	Only emission *reductions* can be traded
Allowances are *allocated* by the regulatory authority	Credits are *generated* when a source reduces its emissions below the standards	Credits are *generated* when a source reduces its emissions below an agreed baseline
Trading must be built into the regulatory structure from the beginning	May develop incrementally as a means of introducing flexibility into existing regulatory structure	May develop incrementally. Does not require a regulatory structure by itself, but rests on the existence elsewhere of a regulatory structure creating a demand
Participants can buy or sell or both	Participants can buy or sell or both	Project hosts can only sell
Participation in the programme is mandatory – the overall emission cap still applies even if sources do not trade	Participation in the programme is usually mandatory – sources must meet existing standards	Participation in the programme is voluntary

Source: US EPA, 2003

A quarter century after its first formulation, the concept of tradable permits has received numerous applications to preserve the environment and natural resources by rationing access to the commons. A survey a few years ago found nine applications in air-pollution control, seventy-five in fisheries, eight in the water and five in land-use control (OECD, 1999a). More recent developments include tradable renewable energy certificates (“green certificates), tradable energy efficiency improvement certificates (“white certificates”), waste management, experiences or at least thoughts in transport and, last but not least, many developments in the field of greenhouse gases (OECD, 2002). Moreover, originally experienced in a relatively small number of countries (mostly the USA), tradable permit experiences are rapidly expanding throughout the world. For example, the EU is finalising its EU-wide CO_2 emissions trading scheme, while China has been experimenting with air pollutant emissions trading in six cities since 1994 – though with limited success (Greenspan Bell, 2003) -- and its government is investigating a possible nationwide SO_2 emissions trading scheme (Yang & Schreifels, 2003).

2.2 Air pollutants

Amongst all uses of tradable permit schemes, the experiences with air polluting emissions trading are the richest in relevant lessons for greenhouse gas emissions trading.

Harrison (1999) provides a review of some early attempts to establish air emissions trading regimes in the US. Starting in the mid-1970s, the US Environmental Protection Agency (EPA) and the States developed several programmes designed to increase flexibility and reduce the costs of achieving the national ambient air quality. They were all baseline-and-credit systems, allowing emission reductions above and beyond legal requirements to be certified as tradable credits. From these programmes, several design issues came forward:

- Netting. This allowed large new sources to be exempt from certain burdensome review procedures if existing emissions elsewhere in the same facility were reduced so that the net addition from the new source was below the level requiring new source review;
- Offsets. Before a major new source could settle in certain areas, it had to offset its emissions by getting an existing source to reduce its emissions by at least the same amount.
- Bubbles. The "bubble" policy allowed firms to combine standards for several different sources into one overall limit.
- Banking. The intention was to allow firms to reduce emissions below the standard and then "bank" the credits for future use or sale.

These programmes had relatively limited results. One reason was the difficulty in establishing the starting point from which credits should be given and the risk of producing "paper credits". Of particular concern were the "shutdown credits" for closing older plants. As such closures can be a cost-effective means to reduce emissions, they should be included in the programme. However, most closures would occur for other reasons – and giving credits in that case would simply increase emissions at another source. These and other concerns led to a development of regulations that basically eliminated the risks of paper credits but increased transaction costs to a point where many trades were discouraged (Harrison, 1999).

The limited success of early programmes nevertheless paved the way for a fuller cap-and-trade nationwide regime established in 1990 under the Clean Air Act Amendment. It caps the total SO_2 emissions from electric utilities and allows them to trade the allowances. Allowances were not defined as property rights, as the environmental community and parts of the administration was concerned about fully privatising the common good. Nevertheless, some security was provided to industries: the EPA cannot change the allocation by itself, only the Congress can. Allocation was made free by the Congress and based upon each unit's average heat input during the period 1985-1987. Phase I capped 263 plants, dropping emissions from 7.1 Mt in 1995 to 6 Mt in 2000. Phase II includes many more plants and the cap rises to 9.48 Mt before falling down to its eventual target of 8.95 Mt. Monitoring is provided by continuous emissions monitoring at stack level. Penalties for non-compliance are severe ($2 500/t). The regime allows for banking but also provides voluntary opt-in.

Another important, but largely similar experience was that of the Southern California RECLAIM programme beginning in 1994. It scheduled a reduction from 1994 to 2003 of 8.3 per cent per year in NO_x emissions and 6.8 per cent per year in SO_x emissions, in the Los Angeles area. The programme included power plants, refineries, cement factories and other industrial sources. It did not allow banking because of the concerns that use of banked emissions would lead to increases in actual emissions in the future and thus delay compliance with ambient air quality standards. (See Section 3.1 for the lessons learned).

A more recent programme is the Northeast NOX Budget Trading system which gathers twelve states in the North-eastern United States and the District of Columbia to deal with regional tropospheric ozone. It is a cap-and-trade programme to reduce NOx emissions from power plants and industrial boilers by about 60 per cent starting in 1999 and up to 75 percent in a second phase starting in 2003 – though only in summer months, when NOx effects on ozone concentrations are greatest. The programme allows banking, but discounts unused allowances for future use – i.e. banking at a discounted rate.

Quite different experiences were those of lead-in-gasoline and mobile source averaging, banking and trading programmes. Although both programmes were intended to help clean the air, they did not directly deal with polluting emissions, and were essentially rate-based trading regimes. The lead-in-gasoline programme helped smooth the progressive near-elimination of lead in gasoline by allowing producers to achieve the new standards on average – not necessarily on each gallon of gasoline. Lead limits were first enforced on a refinery-by-refinery basis, with each refinery allowed to average lead concentration across its total gasoline production. In 1982, the rules were changed to allow trading across refineries and refining firms. In 1985 provisions for banking were added and the lead limit reduced by ten-fold (Ellerman et al., 2003).

Similarly, the US mobile source averaging, banking and trading programmes provided manufacturers of certain mobile sources of emissions the flexibility to deal with differences around emission rate standards. They can average emissions over engine families in the same model year, and/or bank credits to offset future emissions, and/or trade credits between firms. Heavy-duty trucks, automobiles and light-duty trucks, non-road diesel engines in construction work and agriculture, locomotives, marine engines, small engines such as lawn mowers have been integrated into these programmes. Trading between firms, however, has proven exceptional under these programmes, while other features have been extensively used.

Between 1988 and 2000 both Singapore and the US chose to use tradable production quotas to phase-down the use of ozone depleting substances in the context of the Montreal Protocol. What makes the US case of special interest is that the production allowances were distributed to the various producers for free, but the windfall profits that resulted were then taxed away by the Congress (Harrison, 1999).

Finally, one may note that not every attempt to build air pollutant emissions trading has been successful so far. In particular, early proposals in Norway, Poland and the UK failed (OECDa, 1999; Tietenberg, 2003).

2.3 Building GHG trading regimes

Emissions trading has been considered a possible tool for mitigating greenhouse gas emissions since the early 90s, notably by the OECD and UNCTAD (see, e.g., Barrett et al., 1992; OECD, 1992). Emissions trading entered the formal negotiations on the Kyoto Protocol only in January 1997 with a proposal by the USA. It was made part of the Kyoto agreement despite widespread reluctance by many parties and stakeholders (Depledge, 2000).

Operating rules were agreed at COP7 in Marrakech. And, although the Protocol has not yet entered into force, there are a great number of initiatives that aim at instituting emissions trading for greenhouse gas sources, at various levels. These are reviewed below.

2.3.1 Origins of trading in the UNFCCC context

Market mechanisms were incorporated into the agreements made under the UNFCCC beginning with the “activities implemented jointly” (AIJ) concept, and extending to the development in the Kyoto Protocol (in 1997) of the three market-based mechanisms -- emissions trading (ET), joint implementation (JI) and the Clean Development Mechanism or CDM. Emissions trading (ET) is a mechanism that enables countries with legally binding emissions targets to buy and sell emissions allowances among themselves. Annex 1 countries have quantified targets, defined by the allocation of assigned amount units (AAUs), the unit of trade of the Kyoto Protocol. AIJ, JI and CDM are all forms of "project-based" activities; under rules established for these activities, a country may receive emission credits for a specific emissions reduction project undertaken in another country. When participating countries are Parties to the Protocol, such projects will fall under JI rules when both countries have Kyoto commitments and under CDM rules when the host country does not have a target. Banking, but not borrowing, is allowed by the Kyoto Protocol.

The Marrakech Accords in 2001 clarified numerous details on how these mechanisms will work. They instituted the Clean Development Mechanism Executive Board to facilitate the prompt start of the CDM. The Accords deal, amongst other issues, with baselines for the project-based mechanisms, eligibility to engage in those mechanisms, notably in relation with inventories, accounting, transferability and banking. A few aspects are worth noting. The Accords "recognise" that the Kyoto Protocol *"has not created or bestowed any right, title or entitlement to emissions of any kind on Parties included in Annex I"* – thus taking in the "property right" discussion an attitude roughly similar as that of the US in the Clean Air Act Amendment.

The Marrakech Accords also created a Commitment Period Reserve. This requires Annex 1 countries to hold in reserve a number of AAUs which should "not drop below 90 per cent of the Party's assigned amount, or 100 per cent of five times its most recently reviewed inventory, whichever is lowest", thus preventing overselling. An "additional period for fulfilling commitments" of 100 days (often called "true up period") was established.

An agreement on compliance procedures and consequences foresees the creation of a committee with facilitative and enforcement branches, and some consequences for Annex I countries found to be in non-compliance with their quantitative emission objectives. They would include (a) a deduction from the Party's assigned amount for the second commitment period of a number of tonnes equal to 1.3 times the amount in tonnes of excess emissions; (b) the development of a compliance action plan; and (c) the suspension of the eligibility to participate to emissions trading. However, as for most decisions in the Marrakech Accords, the agreement on compliance will have to be reconfirmed by the first Conference of the Parties acting as Meeting of the Parties to the Kyoto Protocol, or COP-MOP. The Marrakech decision to send a draft compliance regime to the COP/MOP recalls that it is a prerogative of the COP/MOP to decide "on the legal form" of the procedure and mechanisms relating to compliance. One possible outcome is that only countries accepting the legally-binding nature of these compliance consequences would be bound by them.

2.3.2 Domestic regimes

Several countries have been implementing or discussing their own emission trading schemes. Each of these systems have varying designs, cover different sectors and have different methods of allocation resulting in issues related to their compatibility and the extent to which they can be linked (see following section for a description of linkages issues).

Table 2 describes trading regimes for which appropriate legislation has been passed while Table 3 depicts trading systems which are still in discussion and not yet legally in force.

In the Danish emissions trading scheme, there is a non-compliance penalty of 40 DKK per tonne of excess CO_2 emissions (approximately €5.4). Payment of the penalty removes any further liability relating to that non-compliance, which makes the penalty equivalent to a price cap. The revenue from the penalties is to be used for energy savings. The magnitude of the penalty was settled as the result of a political compromise in the Electricity Reform and is considered fairly low. Thus it does not necessarily secure compliance under all market conditions contrary to the penalty under the US SO_2 allowance system or the EU penalty

(Pedersen, 2002). The European emissions trading scheme's penalty differs from the Danish system since non-compliance requires that installations pay for the allowances above their quota, plus the penalty tax. The reason for the fairly low Danish penalty is the current lack of symmetry in regulation of the electricity sector in neighbouring countries.

Table 2: **Emissions trading regimes in force in OECD countries**

Country	Coverage and Participants	Initial Permit Allocation	Interface with other instruments
Denmark	CO_2 from electricity production. Started in 2001. A non-compliance penalty tax of 40 DKK per tonne of excess CO_2 emissions	Grandfathering.	A CO_2 tax covers sectors not covered by trading scheme.
European Union	Initially CO_2 only. After 2008 voluntary opt-in option. Covering more than 10 000 sites, emitting about 46% of EU's CO_2. Sectors include electricity and heat, iron and steel, refining, glass, and building material, and pulp and paper. Start-up in 2005. A non-compliance penalty tax of €40 per tonne of excess CO_2 emissions in the first compliance period and of €100 in the second period, plus restoration	During 2005-2007, mostly free allocation by Member states following a common criteria. Up to 5 % auctioning allowed during 2005-2007. Up to 10% auctioning allowed for 2008-2012.	Inclusion of project-based mechanisms under discussion. Possibility to link with other domestic trading schemes.
United Kingdom	On voluntary basis for any firms that commit to binding targets, with the choice of CO2 only or all Kyoto gases. There are several types of participants: 1. **Direct Participants** are required to make absolute annual reductions in emissions against a 1998-2000 baseline in each of the five years of the scheme 2002-2006 on a voluntary basis. They operate on a cap-and-trade basis. 2. **Climate Change Agreement Participants** are companies that already have emission or energy targets set through Climate Change Agreements and are able to use the trading scheme either to help meet their targets or to sell any over-achievement. Many of these targets are relative and a gateway controls the flow of allowances from this sector into the rest of the trading scheme. 3. Anyone is free to enter the market and **trade** allowances on a speculative basis.	Free allocation of allowances. Direct participants bid for reduction commitments in an auction for incentive monies.	Firms that negotiate Climate Change Agreements qualify for 80% discount on UK Climate Change Levy and eligibility for baseline and credit trading. This is integrated into cap-and-trading by the direct participants.

Source: updated from OECD/IEA (2003).

In the UK scheme, both absolute and rate-based targets coexist. A relative target is expressed as an emissions rate per unit of output or activity. Agreement participants – i.e. participants that were previously involved in the Climate Change Agreements, who signed up to targets in exchange for a reduction in the Climate Change Levy – can choose absolute or relative targets. The main concern about the compatibility between absolute and rate-based systems arises when competing firms are covered by different systems, with one perceived as less constraining than the other (Baron and Bygrave, 2002). The sector under a relative target, if it has the easier target, has an incentive to increase output, and companies in this sector will face lower marginal costs. To resolve these competitive issues the UK scheme created a so-called "gateway" between the absolute sector from the rate or unit based sector (Haites and Mullins, 2001). The system only allows for the sale of permits from the relative target sector to the absolute target sector when there has been a net flow of allowances into the rate-based sector.

Table 3: **Emissions trading schemes under discussion in OECD countries**

Country	Coverage	Initial Permit Allocation	Interface with other instruments
Canada	All GHG from large industrial emitters including thermal electricity, oil and gas, mining, pulp and paper, chemicals, iron and steel, smelting and refining, cement, lime, and glass. Start-up pre-2008 possible.	Free allocation determined through sector specific covenants with regulatory or financial backstop.	Possible integration of previous voluntary domestic credit based systems. Development of an offsets system, involving initially forestry and agriculture, and possibly landfill gas, is underway. Links to other trading schemes envisaged.
Japan	To be determined. Trial trading with participants from chemical, oil refinery, car manufacturing, semiconductor, and food industry.	To be determined.	To be determined.
Korea	Registry to be established by 2004 targeting GHG emissions from the manufacturing industry. There are plans to adopt a CO_2 emissions trading system at a later stage.	To be determined.	To be determined.
Norway	All GHGs and all sectors, covering over 80% of emissions. Start-up in 2005.	To be determined, partial auctioning, partial grandfathering.	In parallel with carbon tax from 2005, eventually to replace it after 2008.
Switzerland	Large emitters, companies and energy intensive producers can exempt themselves from the CO_2 law by adopting absolute CO_2 limits, with possibility to trade. Pilot phase 2005-2007.	Based on negotiated agreements. Free allocation.	Tax on fossil fuels will be imposed from 2004 if agreements insufficient. Interested in links to EU emission trading scheme.

Source: updated from OECD/IEA (2003).

2.3.3 Regional and local government schemes

Emission trading systems have also been implemented or are being designed at a state or more local level in countries such as Australia and the United States. Generally, such schemes are designed to provide information and experience to companies and governmental agencies by practical experience of trading carbon dioxide equivalent emissions. Several examples of existing schemes are described below.

The New South Wales (NSW) Greenhouse Gas Abatement Scheme

The NSW Greenhouse Gas Abatement Scheme began on 1 January 2003 and will remain in force until 2012. The Scheme imposes mandatory greenhouse gas benchmarks, on all NSW electricity retailers and certain other parties, including those who elect to manage their own benchmark, to abate the emission of greenhouse gases from the consumption of electricity in NSW. These parties are referred to as benchmark participants.

The scheme sets a State greenhouse gas benchmark expressed in tonnes of carbon dioxide equivalent (tCO_2 eq.) per capita. The initial level set for 2003 is 8.65 tonnes per capita and the benchmark will progressively drop to 7.27 tonnes in 2007 and the scheme will continue until 2012. The State greenhouse gas benchmark is multiplied by the total State population to produce the annual electricity sector benchmark. This represents the total amount of greenhouse gas emissions allowable for the consumption of electricity in NSW.

Each benchmark participant is allocated a share of the electricity sector benchmark based on the level of their electricity sales as a percentage of the total State electricity demand. This allocation is used by benchmark participants as their individual greenhouse gas benchmarks.

Benchmark participants, are required to reduce their emission of greenhouse gases to the level of their greenhouse gas benchmark by off-setting their excess emissions through the surrender of abatement certificates. These certificates are created by accredited abatement certificate providers and can be traded to benchmark participants.

At the end of a compliance year benchmark participants must submit an annual greenhouse gas benchmark statement to the Independent Pricing and Regulatory Tribunal. The statement details their emissions and any abatement certificates being surrendered to the Tribunal to meet their greenhouse gas benchmark. Excess emissions remaining after the surrender of abatement certificates is called a greenhouse shortfall and currently attracts a penalty of $10.50 per tCO_2 eq.

Several greenhouse gas emissions trading initiatives are being planned or implemented in the US at the state level. Those include states such as Massachusetts, Oregon, New York State, New Hampshire, Illinois, North Carolina, Michigan, California, New Jersey and Wisconsin (Jones, 2002).

A greenhouse shortfall can be carried forward to the following compliance year but must be abated in that year or the greenhouse penalty must be paid. Benchmark participants can carry forward a shortfall of up to 10% of their greenhouse gas benchmark in all years of the scheme except 2007.

Regional or state level emission caps in the United States

Massachusetts was the first U.S. state to impose CO_2 emission limits on existing fossil-fired power plants and is currently the only enforced emissions trading regime in the United States. In 2001, Massachusetts adopted regulations limiting emissions of sulphur dioxide, nitrogen oxides, and CO_2 from the six largest existing power plant sources in the State. The six facilities were responsible for emitting 87 per cent of the CO_2 emissions from instate power plants. The same rules required monitoring and reporting of mercury emissions. The rules capped total CO_2 emissions at their then-current levels and created an emission standard 10 percent lower than the existing average CO_2 emission rate. The six plants have to meet the new standard by either increasing plant efficiency or buying credits from approved CO_2 reduction programs.

2.3.4 Companies' trading systems

The year 2002 saw the completion of two corporate emissions trading systems. BP and Royal Dutch Shell concluded internal trading schemes designed to help them achieve GHG emissions as they both begin to participate in external schemes. The internal schemes were mainly designed to better understand the mechanics of trading and help shape the design of future, regulated trading schemes.

The Shell and BP schemes both followed the 'cap-and-trade' approach (see Table 4). Shell's scheme – called the Shell Tradable Emission Permit System (STEPS) – was voluntary, attracting about 30 business units from its 2000 January start. They accounted for approximately 30 per cent of the group's GHG emissions which stood at the equivalent of 97 million tonnes of carbon dioxide (CO_2 eq.) in 1998. STEPS had three objectives: (1) to demonstrate the feasibility of international emissions trading as a low-cost way to reduce emissions; (2) gain experience in emissions trading; and, (3) to identify least-cost opportunities for emissions reduction when compliance becomes mandatory.

BP's scheme was introduced as a mandatory scheme in 2000, after an initial pilot in 1998, which covered 12 business units. Its total emissions were 90.1 million tonnes of CO_2 eq. in 1990.

Table 4: **Companies' trading regimes**

	BP	**Shell**
Emission target	90% of 1990 levels by 2010	90% of 1990 levels by 2002
Number of business units involved	12 in initial (1998-99) pilot, 112 by 2001	30
Nature of scheme	Mandatory within the company	Voluntary
Gases covered	Carbon dioxide and methane	Carbon dioxide and methane
Average prices	2000: \$7.60/tonne CO_2e 2001: \$36/ tonne CO_2e	\$2-4/ tonne CO_2e
Volumes traded	7.2 million tonnes CO_2e	c. 4.5 million tonnes CO_2e
Allocation	Grandfathered, differentiated 'burden sharing'	Grandfathered (initially 98% of 1998 emissions), some auctioning

Source: Environmental Finance (2003)

The Chicago Climate Exchange (CCX)

The CCX is a self-regulatory exchange that administers a voluntary, pilot greenhouse gas emission trading programme targeting emissions and offsets in North America (US, Canada and Mexico) as well as limited offset projects in Brazil. Its framework is a private-sector designed agreement, known as the Chicago Accord, which lays out the rules of this emissions trading programme. Carbon sequestration in soil and biomass is recognised on the CCX through credits generated by projects that are registered and verified on the Exchange.

The core of the CCX is a voluntary commitment taken by members to reduce greenhouse gas emissions during the years 2003–2006 to a level below a historical baseline. Each CCX Member's emission baseline is the annual average of emissions from facilities included in the baseline during 1998, 1999, 2000 and 2001. Baselines are adjusted to reflect acquisition or disposition of facilities. CCX Members are issued Greenhouse Gas Emission Allowances at the inception of the program for the four-year period in an amount reflecting the CCX emission reduction schedule: 2003, 1%; 2004, 2%; 2005, 3%; and 2006, 4% below Member's baseline. This commitment covers multiple gases and multiple industrial sectors.

2.4 Emissions trading in policy mixes

Although emissions trading appears a very promising tool to combat climate change, an effective strategy should not rely solely upon it. The first reason is that of coverage: depending on the design of domestic emissions trading, some sources may not be covered, and would thus require a different set of policies and measures. But even for sources that will be covered by domestic emissions trading regimes, there might be various reasons to complement them with other policies and measures.

Johnstone (2003) mentions in particular the need to overcome technological market failures. The pervasiveness of positive externalities in technology development and diffusion suggests that market forces will not generally provide the optimal rate of innovation in the absence of government intervention. Of other market failures many relate to behavioural responses and may also be addressed through a wide variety of policies and measures.

When a trading regime is introduced, though auctioning has its advantages, grandfathering is more likely to be the norm in initial allocation (see below, 3.4.3). Thus, governments having previously implemented carbon taxes may be reluctant to relinquish the revenue benefits, especially if some other distortionary taxes had been cut when the carbon tax was introduced.

Both in cases of incomplete coverage and market failures, policies other than direct emissions trading may well make use of other types of tradable permit regimes. For example, averaging, banking and trading programmes might be designed to deal with CO_2 emission standards of the automobile industry, that could be found desirable even in the case of an upstream trading regime. Tradable green or white certificates may promote renewable energy and energy efficiency in parallel with carbon abatement policies. Another interesting example would be to develop a land-use permits regime to foster denser urbanisation patterns, thus increasing the use of low-carbon emitting mass transit systems over private car use.

A word of caution is however provided by Sorrell & Sijm (2003). Though they recognise the legitimacy of the various arguments that may justify using several instruments together, they note that *"in many cases there will be trade-offs between long-term and/or non-efficiency objectives and short-term increases in abatement costs. If the policy mix is to gain legitimacy, these objectives and trade-offs need to be explicit"*. Moreover, the inertia in displacing existing and proven instruments, notably taxes, sometimes painfully established in the first place, may lead to *"a mix of overlapping, interacting and conflicting instruments which lack any overall coherence"*. And Sorrel & Sijm conclude: *"In short, a policy mix may easily become a policy mess"*.

Use of trading in a mix of instruments seems valid at both domestic and international levels. Building of domestic emissions trading regimes should not distract governments from seeking to establish a broad base of policies and measures to deal with climate change. The search for establishing a global emissions trading regime, though possibly important, should not distract negotiators from also considering different forms of international collaboration that may usefully support the development of the broad set of new technologies needed to effectively tackle climate change. Within this policy mix international technology collaboration will be an important element (Philibert, 2004).

3. LESSONS LEARNED

This section reviews the lessons that have been learned in the last two decades from both practical experiences of tradable permit schemes and continuous analytical efforts. It considers cost-effectiveness properties of emissions trading and how these might interplay with environmental effectiveness. Issues of competitiveness and leakage are then considered. The basic design features of possible greenhouse gas emissions trading schemes are then discussed.

3.1 Cost-effectiveness

Emissions trading allows countries or companies to purchase emission reductions from others and use them to offset their own commitments, as long as the collective total remains below agreed levels. It is generally recognised that this practice provides considerable cost savings.

A striking example is that of the SO_x trading programme in the US under the 1990 Clean Air Act Amendment, which is estimated to have saved up to 50% of the costs that would have occurred from the same environmental regulations without trading. Other trading systems have not been subject to precise enough ex post evaluations, though the volume of trade occurring in most cap-and-trade regimes, such as the Northeast NOx Budget Programme or the RECLAIM programme, must be interpreted as a witness of cost savings, since these trades have no other purposes than reducing compliance costs. By comparison, earlier credit-based programs led to disappointingly few trades and low cost savings relative to their potential. (Harrison, 1999; Ellerman et al., 2003).

The underlying reasons for these cost savings has to do with what prevents governments from adopting the most cost-effective allocation of emission abatements from the onset. There are two basic reasons. The first one is that no regulator can know the exact cost schedule of marginal abatement costs of all actors as well as these actors can. Collecting all necessary information at a centralised level would require huge administrative resources, while market actors have little incentive to reveal their actual abatement costs to the government. This reason is even more important if the policy must last over decades, since both unabated emission trends and future technology developments cannot be predicted accurately. The second reason is more of a political nature: even if he/she had the necessary information, the regulator may face great political difficulties in implementing the cost-effective allocation of efforts as it may not be perceived as equitable by market players. Important in a domestic context, this advantage becomes essential in an international context.

As a result, the environmental policy without trading would tend to force companies (or countries) to achieve some reductions at a relatively high cost, while other, less costly, possible reductions would remain untapped. Emissions trading allows a smooth reallocation of actual abatement efforts between market players. This is all the more true in a dynamic perspective, when marginal abatement costs evolve due to exogenous circumstance or (possibly endogenous) technical change.

Emissions trading is cost-effective only in effective markets. High transaction costs and various market failures may reduce the cost-effectiveness of emissions trading schemes. However, this proven cost-effectiveness of trading regimes has not prevented the occurrence of price spikes. In the RECLAIM programme in 2000 the price for NO_x rose suddenly from an average of $ 4,284 per tonne to almost $ 45,000, as the demand for electricity soared during the California summer while the availability of imported power from other states declined. Design options that could help smooth the market prices include time flexibility mechanisms (see Section 3.4.5).

Moreover, cost-effectiveness can only be achieved if the market is sufficiently liquid and there are "enough" players on the market. The Danish CO_2 trading scheme illustrates this point. The Danish scheme differs from the UK-ETS and the EU-ETS in the way that it only involves emissions from the power sector, whereas the EU-ETS covers 6 sectors and the UK explicitly excludes the generation sector. The Danish market was very inefficient because there were only two dominant players, receiving 93 per cent of the allowances between them (Pedersen, 2002). Due to power company mergers in the wake of the electricity reform, the CO_2 allowance market is dominated by the two main power companies, Elsam and Energi2. The volume of exchange of the Danish CO_2 allowance market appeared to be too small too sustain a "carbon exchange", hence trading has essentially relied on bilateral trading.

3.2 Environmental-effectiveness

One first way to look at the environmental effectiveness of emissions trading is simply to note that the total allowed emissions remains constant whatever permit trades occur. While companies or countries buying permits will emit more than their initial endowment, others – the sellers – will emit less. For the environment, this may or not make a difference – depending on the characteristics of the pollutant at stake. For example, SO_2 emissions might have local as well as regional detrimental effects; thus, a regional tradable permit scheme involving SO_2 emissions trading may have the same regional effects than a similar regulation without trading, but differing local effects[2]. In case of climate change, as most greenhouse gases have no local effects and rapidly mix in the global atmosphere, the geographical origin of the emissions does not matter.

Again, the US experience with SO_x trading illustrates the environmental effectiveness of emissions trading. Compliance was extremely close to 100%, which is rarely the case with environmental regulations. In fact, emissions have been reduced ahead of schedule, due to "banking provisions" allowing companies to save unused emission permits for future use. Although future use of these saved allowances will put future emission levels above the cap at that time, on average this is not detrimental for the environment (Ellerman et al., 2003.

In the case of RECLAIM, however, the 2000 price spike led the regulator to suspend participation from electric generators; generators were allowed to pay a mitigation fee of $ 15,000 per tonne when they exceeded their caps, with fee revenues used to pay for emission reductions elsewhere. The NOx emissions exceeded the cap for 2000 by about six percent. This failure did not originate in the trading regime but could be considered as an outgrowth of the electricity crisis in California during the summer of 2000. It is unlikely that a control-and-command programme would have performed better. Most of such programmes are based on regulating emission rates per unit of output; unexpected growth in output would have led to growth in emissions without compensatory measures equivalent to those financed by the excess fee in the RECLAIM programme (Ellerman et al., 2003).

The high level of compliance usually exhibited in cap-and-trade regimes arises as an effect of the flexibility given to participants in achieving their commitments. Those facing high marginal costs or even technical impossibilities have the means to comply by buying allowances on the market – while under a command and control regime they would likely ask – and get – at least temporary exemptions. Environmental effectiveness, however, cannot be limited to considerations about compliance. More environmental benefits may result from ambitious objectives even if not fully complied with, than from weak targets easy to comply with.

[2] Ex-post evaluation of the US experience has revealed that this much-feared "hot spot" problem hardly materialised. Ellerman (2003) suggests that due to the capital intensive character of deep abatement technologies, markets direct abatement to larger and heavily utilised sources that are also the most damaging for the local environment.

A second way to look at the environmental effectiveness of emissions trading is precisely to consider it in relation with its cost-effectiveness. From a policy point of view, in a recent review of a range of tradable permit experiences, Tietenberg (2003) writes that *"the evidence seems to suggest that, by lowering compliance costs, tradable-permit programmes facilitate the setting of more stringent caps."* Ellerman et al. (2003) note that the inclusion of emissions trading in the Clean Air Act Amendment *"broke what had been a decade-long stalemate on acid rain legislation"*. Similarly, the Chair's summary of the OECD Ministerial Council Meeting held in May 2004 states that *"governments could achieve the same results in protecting the environment at significantly lower cost through the greater use of more cost-efficient instruments in many countries. Alternatively, more ambitious environmental objectives could have been achieved for little or no additional cost."*

From an economic perspective, the optimal level of abatement should be fixed at the point where increasing marginal abatement costs and decreasing marginal policy benefits equalise[3]. Emission standards that are part of the average, trading and banking programmes were explicitly set up according to cost predictions based on trading, i.e., at a more stringent level than otherwise. While uncertainties on future costs and benefits may make such optimisation difficult, as emissions trading reduces costs it justifies setting a more ambitious environmental objective, either from the onset on the basis of predicted costs, or as the policy evolves over time, after first steps have revealed more information on actual abatement costs.

Longer term environmental effectiveness, however, must be looked at in the context of induced technical change, and the analysis becomes more complex – and controversial. On the one hand, it is often argued that economic instruments such as emissions trading or taxes provide a permanent incentive for technology development beyond the legal standard, while "command-and-control" regulations do not (Stavins, 2003). Actual evidence of such an effect, however, is sparse, even from the experience of SO_2 trading in the US (Ellerman, 2003).

On the other hand, it has been argued that "too low" costs of achieving a short-term target would give too little incentive for technology development and thus limit the possibilities for more ambitious targets in the future (Grubb et al., 1999, p.219). Indeed, the need to develop some technologies currently in their infancy (such as, e.g., renewable energy technologies) may justify that the emission abatements they can provide today be bought at a higher price than average. Helping early market deployment will speed cost reductions thanks to learning-by-doing processes, and thus reduce the cost of future emission reductions (Philibert, 2003). The argument mentioned by Grubb says that this may be best provided by restrictions on trading. However, this argument is not fully convincing. The low cost in achieving short-term objectives would, to the contrary, encourage regulators to tighten them. It might be more appropriate to provide the necessary incentives to new technologies through other instruments – such as the "green certificates" for renewables, for example.

3.3 Competitiveness and leakage

The leakage problem, where production facilities relocate themselves to avoid the regulations, seems a potentially serious problem. Leakage problems can arise either within countries (if certain sized plants or certain sectors are exempt) or between regulated and non-regulated countries, particularly if greenhouse gas caps result in considerably higher energy costs or production costs in regulated countries.

[3] As Coase (1960) wrote in a more provocative language, *"the aim of such regulation should not be to eliminate smoke pollution but rather to secure the optimum amount of smoke pollution, this being the amount which will maximize the value of production."*

Emissions trading has the potential to significantly affect the prices of electricity and thus the price of energy intensive products (Reinaud, 2003). Furthermore, international trade in goods which are energy intensive tends to favour the economies of non-participants in an international trading scheme. Key effects on non-participants have been examined in many models (Edmonds and Scott, 1999). One consequence of carbon control is that carbon-intensive economic activity may have an incentive to migrate from countries where it is penalised to non-participative countries where production may become more profitable. Clearly, however, costs associated with greenhouse gas abatements will only be one element amongst many others in firms' decisions about where to locate their activities and investments. But for some energy intensive industries at least, carbon costs may become more important as the cuts get progressively deeper.

There is an on-going debate on whether the allocation mode (grandfathering versus auctioning) mitigates the leakage problem or not. Companies' marginal production costs are equally increased whether the allowances are distributed for free or bought. This is because the production always competes with the opportunity to sell the allowances on the emission allowance market. Therefore, this opportunity cost exists whether the allowances were grandfathered or auctioned. In the former case, the initial allocation can be assimilated to a lump-sum subsidy.

However, the initial allocation mode strongly impacts on companies' financial profitability of new investments – as well as on the value of stranded assets. If companies have to purchase 100 per cent of their allowances, competitors in the non carbon constrained zone, and/or competitors in carbon constrained zone where allocation is free, will be advantaged. In this case, the risk of leakage might be significant (although many other factors enter companies' decisions). If, however, allowances are freely allocated, then the leakage risk will be lower.

3.4 Other design issues

The design of a trading scheme should consider several features in order to enhance the achievement of the environmental objective and facilitate the efficient operation of a competitive and cost effective market. The main design elements include: coverage of the regime, allocation modes (upstream and downstream, grandfathering and auctioning), compliance systems, and issues such as banking and borrowing. The following sections assess which of these features potentially create barriers to linking different domestic trading regimes.

3.4.1 Coverage

The effectiveness of an emissions trading system in achieving least cost abatement will be highly dependent on coverage. The question of coverage refers to the sources or categories of emitters that are included in the emissions trading scheme as well as the gases that are covered. Coverage will vary from country to country as each will have different emission profiles, and may already have in place policies and measures to cover specific sectors which therefore may not need to be covered by the scheme. There are also different political motivations for covering certain sectors (Baron and Bygrave, 2002). Limiting a scheme to certain sectors and gases will protect certain industries whether deliberate or not (Diringer, 2002).

If a trading system can achieve widespread and consistent price signals, it will drive emission reductions in those areas of the economy where they can be achieved cheaply. Generally, the more sectors and gases that are covered in an emissions trading scheme, the greater the potential for liquidity and market efficiency. The higher the number of sources covered, the lower the total cost of compliance. Therefore, linking different emission trading schemes with different coverage leads to potential cost savings as there are different costs among participants (ERM, 2002). The same is also true for gases covered in national trading schemes. A system covering all six GHGs will generate lower compliance costs than a system covering just CO_2 (Baron and Bygrave, 2002).

3.4.2 Upstream versus downstream

The terms "upstream" and "downstream" allocation refer to the point of application of the overall limit on GHG emissions in the production and consumption chain and define both the type of product that is traded in the market and the market actors (KPMG, 2002). In an upstream design, the entities accountable for meeting a cap are producers and importers of fossil energy. In a downstream design, the regime applies to end-users of fossil fuel energy, i.e. the actual emitters of CO_2 and sources of other greenhouse gases (Baron and Bygrave 2002). The important difference of an upstream emissions trading scheme from a carbon tax is that the amount of allowances for selling fossil fuel is limited by the authority. The price of allowances will necessarily increase until the demand for fossil fuels matches the restricted supply.

Having first considered using "upstream" emissions trading, in 2002 Canada shifted in favour of "downstream" emissions trading. Niizawa et al. (2003) assert that in Japan, importers of fossil fuels should hold allowances to sell them in Japan. The major advantage of the upstream emissions trading is that it increases coverage to most sources – small sources as well as moving sources like cars. The monitoring cost would be lower than in the downstream system because the number of fossil fuel suppliers is smaller (around 300 in Japan). The authors declare that the broad coverage of sources means administrative effectiveness, certainty and efficiency of the policy. However, the potential trade-off is the lack of response of small consumers to price signals.

A downstream design has the potential to become impractical with potentially large numbers of participants if it is to include small businesses and domestic households, leading to high monitoring costs (KPMG, 2002). The choice of coverage in a downstream scheme results in an implicit trade-off between administrative costs (the number of sources monitored) and economic efficiency (the more sources, the more cost savings the system brings). In a downstream scheme, the market would be more liquid as there are more participants, and as capped sources have a more direct incentive to control their emissions, the system could be more efficient in revealing the true marginal cost of reductions (Baron and Bygrave 2002).

The coverage issue is linked with the allocation issue (see below). For instance, most authors consider that upstream allowances should not be allocated for free. There are two reasons. Firstly producers or importers of fossil fuels may get a windfall profit by the regulation because carbon constraint leads to an increase in the price of fuels. They will pay an average cost for their permits lower than the marginal cost passed on to the end-users. Bovenberg and Goulder (2001) analysed the distributional implication of upstream emissions trading. Their conclusions are that only a small part of allowances should be allocated for free to compensate the losses incurred by upstream firms, and that a small part of the auction revenue is enough to compensate the downstream firms through reductions to the industry-specific corporate taxes. Both results depend on assumptions about the underlying economy.

Hargrave (2000) proposed a hybrid approach to greenhouse gas emissions trading using both upstream and downstream allocation. He suggests that such a scheme could cover large industrial point sources, electric power generators, oil refiners, natural gas processing plants and local distribution companies selling natural gas. Such a system would be preferred to a downstream system covering large point sources complemented by non-trading policies and measures, because it would provide full coverage while ensuring cost-effectiveness. It would also be superior to a full upstream regime by providing large market players with precise price signals, and would allow combining two types of allocations: free allocation for the downstream segment, so that energy-intensive firms, especially those facing international competition from unregulated areas, would have their assets and profitability preserved; and auctioned allocation for the upstream segment.

3.4.3 Allocation

Under a cap-and-trade regime, several methods exist for the initial allocation of allowances, the main ones being auctioning and grandfathering (Harrison and Radov, 2002, Burtraw et al., 2002).

- In the case of auctions, participants in the trading system have to purchase the allowances from the government to cover their expected emissions. The returns of the auction could then be recycled back into the economy, for example by means of reducing other distortionary taxes. One of the advantages of auctioning allowances is that it avoids the difficult negotiation of source-by-source allocations. Instead, each source decides how many allowances it needs to buy to cover its projected emissions, and bid for these allowances on the marketplace.

- In the case of grandfathering, the distribution of allowances is free of charge and is based on the past emissions levels. The base period or historical emissions principle starts from emissions in a chosen period, either one reference year or the average over several years. While this might be termed "pure" grandfathering, the term 'grandfathering' also refers to distributions using benchmarks, for instance regarding emissions per unit of output, but again on an historical basis. An example is given by the US nationwide SO_2 trading regime.

In the European carbon dioxide emissions trading scheme, emission caps are fixed for each 5-year commitment period but can be revised and modified for the following commitment period. In contrast, under the US SO_2 regime, SO_2 emissions were allocated to the emitters for a period of 30 years.

The choice of initial allocation might have tremendous effects on the overall welfare costs of introducing a trading programme. According to Burtraw and al. (2001), the auction is dramatically more cost-effective than the other approaches – roughly one half of the societal cost of free allocation. However, auctioning imposes greater costs on sources overall because they must buy an allowance for every emitted tonne – on top of the costs to reduce emissions. Auctioning may turn out to be more costly for them than a command-and-control regime without trading. As notes Tietenberg (1999), *"Only a transferable permit system that allocates permits free of charge to sources on the basis of their historic emission rate would guarantee that existing sources would be no worse off than they would under a command-and-control system imposing the same degree of control"*.

Other studies have explored the effect of allocation modes on companies' equity or asset value (equal in theory to the discounted expected profits over medium-long term) based on a detailed description of various sectors, technologies and fuel use. In a scenario where all US energy-related CO_2 emissions would be covered by a cap-and-trade system, Smith and Ross (2002) find that grandfathering 100 % of CO_2 allowances would result in a 50% increase in the equity value of the power generation sector. They also show that 9% of all allowances would need to be grandfathered in order to compensate for the loss of equity value incurred by certain sectors (i.e., 91% of total allowances would be auctioned) (Baron and Bygrave, 2002).

Auctioning the entire volume of permits provides a new source of government revenue. Returning auction revenues to consumers instead of increasing government budgets is known as revenue recycling. Auction revenues could allow a reduction of pre-existing distortionary taxes and increase the public welfare. Thus, a revenue-neutral shift away from existing income taxes and toward allowance auction revenues could generate greater economic performance than would be achieved under the same emissions cap regime in which the allowances were entirely grandfathered (Smith & Ross, 2002). The auction price reflects an environmental concern and emerges as a corrective rather than a distortionary levy (Bohm, 1999).

On the other hand, existing literature on this issue usually compares free and auctioned allocations of the same amount of allowances, as this facilitates effective comparisons. The trade-off faced by policy-makers might, however, be of a different nature, as it might be possible to negotiate a higher level of abatement under a free allocation than under an auctioned one. Financial and economic costs for companies would be different in both cases, as would be the welfare costs for the society as a whole. Policy makers would have to consider not only various ways to recycle the auction revenues, but also the differing burdens that other parts of the society would incur in both cases to contribute to achieving a country wide commitment on greenhouse gases emissions.

In sum, free allocation seems to be very helpful in introducing downstream emissions trading, particularly with respect to energy-intensive industries facing international competition from unregulated countries: "*using a grandfathering approach to the initial allocation has been a necessary ingredient in building the political support necessary to implement the approach. Existing users frequently have the power to block implementation while potential future users do not.*" (Tientenberg, 2002). However, allocation does not need be totally for free. If the competition arises mainly from less energy-intensive industries, a progressive elimination of the implicit lump-sum subsidy represented by free allocation would be needed to fully internalise the carbon externality.

In the case of upstream regimes, auctioning seems preferable. If politically difficult or impossible, an alternative might be a free allocation from the onset, with the windfall profits then taxed away as they appear, following the precedent set by the US Congress in the case of the ozone-depleting substances.

3.4.4 Compliance

In mandatory domestic or corporate trading schemes, entities are under the surveillance of a designated "authority" and are sanctioned in case of non-compliance. The UK ETS is often considered as a success in that it did encourage a large amount of trading activity and compliance. 31 of the 32 Direct Participants complied with all the requirements of the scheme. From a design standpoint, it showed that cap and trade systems allow efficient management of compliance positions, whereas baseline and credit systems encourage concentrated periods of activity with no degree of constant liquidity on both the buy and the sell side. This is because in a baseline and credit system, credits only are available at the end of the year, whereas allowances under a cap-and-trade regime, are available all year. This can significantly affect the price, making compliance management more difficult (Kessels and Hennessy, 2004).

In the case of voluntary domestic or corporate regimes, no sanctions are taken in case of non-compliance. There is little incentive for net buyers to remain in the scheme. This is illustrated with the two corporate trading regimes in place in both BP and Shell. BP's mandatory target, announced in 1998, was to reduce GHG emissions to 10 per cent below 1990 levels by 2010 – a goal that was met by the end of 2001. Shell, on the other hand, under its voluntary regime, did not reach its target before the end of its scheme. De Coninck and Van der Linden (2003) assessed that voluntary participation was part of the problem, creating a great excess of supply compared with demand for credits.

Enforcing compliance in international emissions trading is more difficult than in local and national trading regimes. Responsibility for non-compliance at international level will reside with the participating sovereign nations (Peterson, 2003). Haites and Missfeldt (2002) cite Chayes and Chayes (1998) who note that under existing international agreements, sanctioning authority is rarely granted by treaty, rarely used when granted, and likely to be ineffective when used. Even though the international emissions trading scheme under the Kyoto Protocol might ensure that a penalty system for trading is designed, a party that finds a penalty to be too high might even withdraw from the Protocol and avoid penalties.

3.4.5 Time flexibility

Allowances not used in the trading period for which they are issued may be banked for use in a later trading period. The banking of allowances can help firms meet absolute emission targets by providing flexibility in the way in which large investments can be undertaken. It also offers an incentive to take action early and gain credit for it. Heavy use of banking in both the US sulphur-allowance and lead credit-trading programs led to early reductions and substantially lower overall costs of compliance (Tietenberg, 2003). Conversely, the lack of banking provisions in the RECLAIM programme probably aggravated the 2000 price spikes (Ellerman et al., 2003). Banking also allows firms to smooth their emissions profile through the business cycle, and to manage price volatility. Nevertheless, restrictions may be placed on the number of allowances that may be banked from one period to another.

Borrowing also provides flexibility over time similar to that provided by banking. Like banking, there may be an economic interest, allowing firms to adjust their reduction schedule to their investment programmes to modernise plant or extend capacity. It also assists adjustments made necessary by the business cycle or changes in circumstances such as weather, which influence the degree of economic activity of some emission or abstraction sources.

However, borrowing gives rise to two main concerns (OECD, 2001). The first deals with environmental integrity, firms may launch into borrowing against future rights and thus may, for several years delay their emission reductions. The second is that after using all of their allowances and their permitted level of borrowing, companies may tell the authorities that they are unable to comply with the initial cap and might renegotiate environmental constraints to their advantage. This is even truer in an international context.

3.4.6 Absolute and relative targets

In designing GHG emission trading schemes, countries have the choice between different types of targets. Most commonly the choice is between absolute targets - expressed as total emissions during a specified period, or relative/rate-based targets - expressed as an emissions rate per unit of output or activity such as GDP or energy consumption, or per unit of input. Targets established under a country's domestic GHG emissions trading scheme may be different that country's overall GHG emissions target. For example, a country could design a domestic emissions trading scheme based on relative targets yet still have an absolute GHG emissions target (e.g. this type of situation is envisioned in Canada's plans to meet its Kyoto commitment).

A number of authors (Burtraw et al. 2001, Haites and Mullins 2001, Harrison and Radov 2002, Gielen et al. 2002) have noted the economic incentive to increase output under a relative target but not under an absolute target. Others note the increased complexity in rate-based schemes when measuring emission reductions across sectors that generate different products. One reason is because input or output (depending on the methodology or approach chosen) as well as emissions must be monitored under a relative target, whereas only emissions need to be monitored under an absolute target. That is, relative targets will likely require two sets of measurement, verification and reporting systems (Baron and Bygrave 2002).

Merging or linking emission trading schemes with different types of targets is technically possible and typically desirable from an overall economic perspective, though there can be implications on output and overall emissions levels and thus potentially on the environmental integrity of the schemes. There can also be competitiveness issues for entities that deal across different systems (although these may still exist whether or not schemes are linked). Nevertheless, some design solutions can be implemented that reduce these impacts.

Blyth and Bosi (2004, draft) specifically examine how domestic schemes outside of the EU might link with the EU-ETS. Some of these schemes will have absolute targets, while others will be based in relative targets. For example, at this stage Norway's DET will use absolute targets whereas the Canadian DET will be based on rate-based intensity targets using sector-specific covenants, with allocation based on projected intensities in 2010.

3.4.7 Opt-in and Opt-out provisions

In some circumstances the design of mandatory domestic GHG emissions trading schemes allows for entities that are not explicitly covered by a trading scheme to voluntarily "opt-in" or "opt-out" of a trading scheme. In the case of opt-out provisions, these are usually accompanied by condition that the entity opting-out is covered by another instrument or trading scheme with similar objectives and requirements. While opt-in provisions allow for installations and/or sectors not automatically covered under a DET to voluntarily participate in an emissions trading scheme, opt-out provisions allow installations to exit or be exempted from an emissions trading scheme.

Opt-in

Opt-in provisions allow for installations, sectors and/or gases that are not covered in a mandatory emissions trading scheme to voluntarily be included in that scheme. An opt-in feature is useful because environmentally and cost-effective solutions for reducing concentrations of greenhouse gases should be as comprehensive and global as possible. Opt-in provisions have benefits in terms of increasing the supply of allowances, incentivising abatement in installations/sectors not initially included in a trading scheme, in familiarising participants with the requirements of emissions trading, and reducing compliance costs (Ellerman et al., 2003, Sorrell 2003).

Allowing activities / sectors to opt-in to the trading scheme will nevertheless leave only the higher cost options for activities and sectors left outside the system but still having a GHG emission obligation. This may make emission reductions for the sectors not covered by the domestic cap-and-trade scheme but covered by another instrument more expensive than in the absence of the opt-in provision. But the share of national emissions not covered by the scheme will be reduced.

Opt-Out

Opt-out provisions in an emissions trading scheme allow installations and/or sectors to withdraw or be excluded from that scheme. Most commonly an opt-out provision would be accompanied by a requirement for the installation opting out to be included by another policy measure with similar emission reduction requirements. This would allow maintaining some kind of level playing field in terms of the mitigation effort required by different economic actors. There may also be the situation where an entity is already covered by an existing trading scheme, and can thereby opt-out of a new trading scheme on the grounds that it is already covered by the existing scheme. Nevertheless, the presence of opt-out provisions generally creates an incentive for entities to move to less stringent schemes.

Opt-out provisions can therefore have impacts on environmental effectiveness of trading schemes as well as implications for economic efficiency. Nevertheless, these issues may only exist in the short to medium term when there are different eligibility and participation across schemes. A merging of compliance regimes and participation may occur over time, and compliance regimes and participation become more consistent, e.g. with Kyoto trading and after Phase 1 of the EU emissions trading scheme.

3.4.8 Linkages

There are a number of benefits to linking emission trading regimes. The underlying assumption is that linking is environmentally neutral and is positive for emissions trading market efficiency and positive for the economy overall (Blyth and Bosi, 2004). Barriers to linking may reduce these benefits. Linkage between different trading schemes requires that several elements be considered when designing those trading markets. The important issues that should be looked upon when designing the system, but are not barriers to linking are listed below.

- Different **coverage** in the variety of national schemes (Haites and Mullins, 2001);

- The coexistence of different emission trading schemes using **absolute and relative targets** (Sorrell, 2003; Baron & Bygrave, 2002);

- **Allocation modes** (upstream versus downstream, auctioning versus grandfathering) (Baron and Bygrave, 2002);

Linkage of systems with different modalities for the following features could be problematic:

- **Monitoring, accounting and verifying** are important elements to consider when linking trading schemes. If for example one trading regime does not include adequate monitoring, a source could sell unqualified allowances resulting from inaccurate GHG monitoring to others, undermining the environmental integrity of the regime (Mullins and Haites, 2001; Peterson, 2003);).

- Another element to consider when linking trading schemes are **compliance mechanisms.** It is not straight-forward to combine the fixed penalty type compliance regime with a scheme that has a price cap or safety-valve type regime. If price-caps are not comparable across linked systems, the lowest price-cap level will probably dominate (Peterson, 2003).

- **Mutual recognition of trading units** (Blyth and Bosi, 2004).

4. LOOKING FORWARD

The two previous sections have described a number of past, on-going or forthcoming emissions trading regimes dealing with air pollutants, including greenhouse gases, and drawn from these experiences as well as from theoretical insights a number of relevant lessons. This forward looking section explores how future greenhouse gas emissions trading regimes might be shaped, at both international and country levels. It first looks at the potential future role of emissions trading in dealing with climate change at both domestic and international levels, identifying its strengths and weaknesses. It goes on to consider ways to alleviate these weaknesses, notably those dealing with abatement cost uncertainty.

4.1 Emissions trading and climate change

Achieving the objective of the Convention on Climate Change – stabilizing atmospheric greenhouse gas concentrations – will require deep cuts in emissions. In the case of carbon dioxide, stabilisation – at any level – will require bringing down global energy-related emissions to a tiny fraction of their current levels. A key determinant in the final level of concentrations is the timing of reductions: the lower the chosen level for stabilisation, the sooner the reduction in global net CO_2 emissions needs to begin (IEA, 2002).

There are two aspects of the climate change mitigation problem that favour the use of emissions trading as a policy tool. The first is that most greenhouse gases have no direct local environmental effects[4]. They rapidly mix in the atmosphere, and where they are emitted does not matter. The second is the importance of lowering the cost of emissions reductions.

Though a considerable amount of energy savings could probably be achieved at no net cost, there may not exist easy and cheap solutions to sufficiently reduce emissions while fuelling the world economy and satisfying the energy needs of growing populations. Depending on the level of stabilisation chosen, costs may be considerable (IEA, 2002). In all cases, it makes full sense to achieve any given objective at the lowest possible cost – or to try to get the most emission reductions for a given expenditure. The possible economic implications fully justify the use of economic instruments on the largest possible scale. Cost savings are largest when the market is broad and the possibilities for reductions heterogeneous.

Although various behavioural changes might help achieve stabilisation of concentration, deep technology changes will also be required. While policies and measures specifically designed to “push” research and development might bring an invaluable contribution to such technical change, dissemination of innovation is unlikely to be rapid enough in the absence of long-term price signals that only economic instruments such as either taxes or tradable permit schemes would provide (Philibert, 2003).

Emissions trading seems to offer two considerable advantages over other economic instruments to deal with climate change. The first might be the flexibility given to governments at domestic levels to fine tune the balance between free allocation and auctioning so as to improve the acceptability of the new regulations to incumbent emitters on the one hand, and maximise social welfare through revenue-recycling, on the other. The second is the flexibility that the allocation process provides at the international level, which allows a negotiation to reach an acceptable distribution of efforts (without having to consider its cost-effectiveness)[5].

4.1.1 The need for a global regime

Global climate change will eventually require a global solution, implying the participation of as many countries as possible into the mitigation action. A global emissions trading regime is not only the most cost-effective one, but it might also facilitate global participation since one of its properties is to allow negotiators to focus efforts on the acceptability of the initial allocation of permits amongst countries. Emissions trading is potentially superior in terms of global welfare to any “second-best” solutions that would lead to differentiating the costs of abatement by countries, due to the redistributive effect of the initial allocation of permits (Shiell, 2003).

[4] with the notable exception of tropospheric ozone which itself is a secondary pollutants resulting from NO_x, CO and VOC atmospheric levels

[5] The question of international allocation of efforts (or permits) has been approached in the AIXG context (see Philibert et al., 2003.).

Numerous modelling exercises have shown how establishing a global trading regime would reduce the overall costs of achieving a given climate target – notably that of the Kyoto Protocol. Few have shown how global trading could alternatively allow in the long run the achievement of a more ambitious environmental objective. OECD (1999b) compares three different scenarios for global participation, that lead to three different levels of GHG concentrations by 2200:

- "Kyoto forever": Annex I Parties limit their emissions at the levels specified in the Kyoto Protocol, other countries are not constrained. Atmospheric concentrations would not be stabilised under this scenario;
- "740 parts per million in volume (ppmv)", representing a doubling from current concentration;
- "550 ppmv", roughly twice the concentration at pre-industrial times.

A comparison of the global economic cost over a 2010-2050 horizon provides striking results: Annex-I countries would spend as much to achieve a "Kyoto forever" emission objective without trading – no stabilisation of concentrations – as they would to reach stabilisation of concentrations at 550 ppmv if global emission trading is made possible. Furthermore, most of the scenarios for allocation targets that involve trading deliver net economic (i.e., trading) benefits to non-Annex I regions, from a scenario where they would take no action to reduce their GHG emissions. These results – and many others – demonstrate the potential for large cost savings, thus more ambitious targets, in a global regime with emissions trading.

Another reason for a preference for a global regime is that it would avoid the leakage problems which potentially arise from partial regimes and which might reduce efficiency. This effect does not depend on the initial allocation. Even if some countries were allocated surplus emissions beyond their needs, greenhouse gas emissions would have the same opportunity cost everywhere. Any additional emission in such countries would represent a lost opportunity to sell. This loss entails the same cost as buying the permits to cover this emission in a constrained country. By contrast, a project-based mechanism could only reduce leakage risk if baselines were based on the standards applied in the investor country – not those of the host country – thus adding the same opportunity cost to emissions in both constrained and unconstrained countries. This is not currently the case with the Clean Development Mechanism.

Properly designed to offset the risk of impeding economic growth, an international emissions trading regime could finally provide developing countries with various benefits – beyond lower climate change impacts. It could be a driver of technology transfers as well as some financial benefits. It could also offer some ancillary benefits with lower emissions of locally-detrimental pollutants, and help forge new strategic relationships at both the governmental and private sector levels.

4.1.2 Emissions trading vs. carbon taxes

Emissions trading and, more broadly, tradable permit schemes belong to the family of so-called "economic instruments for environmental protection". Environmental taxes represent the most important alternative. They work in the same cost-effective way, equalising all marginal abatement costs.

However, emissions trading and taxes differ significantly on various grounds. A first difference is that with environmental taxes, market actors usually have to pay for all their emissions. With emissions trading, depending on the methods for allocation, market actors can either pay only for emission reductions (if permits are allocated for free), or pay for all their emissions (if they are not).

On the other hand, having market actors paying for all their emissions is often promoted as a superior solution. It would open the possibility of a fiscal reform that would tend to "tax the bad" (pollution, externalities) rather than "taxing the good" (i.e., capital or labour) and simultaneously foster the economy or employment while combating the polluting emissions. This is known as the "double dividend" theory (see, e.g., Parry & Bento, 1999).

The implications of various allocation methods have been discussed in the previous section. What is important to emphasise here is that emissions trading offers governments much flexibility on this point, allowing them to combine various modes to associate their advantages and mitigate their downsides. It has proven more difficult to shape environmental taxes in order to make companies pay only for emission abatement.

A second difference arises from the fact that, with tradable permit schemes, the regulators do not need to focus on a cost-effective allocation: they can instead focus on an equitable and acceptable allocation, letting markets reorganise the needed efforts in a cost-effective manner. This stems as a result from the fact that the ultimate allocation of abatement efforts is independent of the initial allocation[6]. Environmental taxes do not offer the same possibility. This difference might be considerable in the case of international GHG trading regimes

A third difference has to do with the behaviour of both instruments in face of abatement cost uncertainties. Taxes offer certainty on the marginal cost of abatement that will be incurred – the level of the tax. But they offer no certainty on the level of emissions – and no certainty on the total costs incurred. In other words, taxes adjust the level of abatement to actual costs. By contrast, tradable permit schemes offer certainty on the emissions levels – at uncertain costs.

Which certainty, and thus which instrument, should be preferred, depends on some basic features of the problem at stake. If marginal abatement costs increase rapidly with the level of abatement, while marginal damage is relatively constant, taxes should be preferred. If, on the contrary, the marginal damage increases with emissions at a more rapid rate, permits should be preferred (Weitzman, 1974)..

From this perspective, the climate change problem theoretically favours taxes over emissions trading due to its long term and cumulative nature. It will require using technologies that do not exist yet, to reduce emissions from unabated trends that are not accurately known. The costs of stabilising the greenhouse gas concentrations are thus largely unknown. It is the build-up of atmospheric greenhouse gas concentrations that drives climate forcing and climate change – not the instantaneous emissions. As a result, marginal damages are likely to be relatively constant (at least over decadal periods of time) while marginal abatement costs, linked to day-to-day emissions, are not.

Pizer (1997; 1999; 2001) and Newell & Pizer (2000) have shown that expected net benefits (benefits minus costs) of a climate policy based on quantified objectives (i.e. fixed targets with no time flexibility) would be much lower than expected net benefits of an equivalent climate policy based on taxes.[7]

Another possible implication is that any instrument that could reduce expected costs (as does, for example, a price cap by "shaving" the worst possible cost outcomes) could allow a more ambitious policy to be chosen from the onset, so that expected (gross) benefits remain the same or even greater than would be the case without that instrument, while expected costs would still be lower (Philibert, 2002a; IEA, 2002).

[6] This result is usually known as the so-called "Coase theorem".

[7] This point is sometimes misunderstood. Both policies are equivalent under "best guess" on abatement costs – and if the guess turns out to be right, both policies will, of course, cost the same. But before uncertainty is resolved, what matters for taking sound decision are the expected costs, i.e. the average of all possible cost outcomes, weighted by their probabilities of occurrence. Expected costs are lower with taxes because if actual costs turn out to be high market actors will pay the tax instead of abating emissions at a higher price.

The possibility of abrupt climatic changes might modify these results, if only we had an idea of the GHG concentrations most susceptible to trigger off such “non-linear climate events”. Uncertain as they are, these possibilities do not really modify the rate of change of marginal expected benefits. Even if we knew for sure that a given temperature change would drive a catastrophe, a quantity policy would only have a relatively small advantage over a price policy, because in both cases over-control would be necessary, given the uncertain relationship between GHG emissions and temperature changes (Pizer, 2003).

Modelling exercises confirm this analysis. Lecocq & Crassous (2003) use a partial equilibrium model of the international allowance market to quantify the economic consequences of the main post-Kyoto quota allocation rules proposed in the literature, and to assess how robust these consequences are to uncertainty on future population, economic and emission growth. They show that, regardless of the rule selected, the prices of allowances and the net costs of climate mitigation – for all Parties – are very sensitive to uncertainty and in some scenarios very large. This constitutes *“a strong barrier against the adoption of any of these schemes if no additional mechanism is introduced to limit the uncertainty on costs”.*

In conclusion, cost uncertainty represents one of the main potential problems of using emissions trading to combat climate change. However, as will be discussed below, there are several ways to fix or alleviate this problem such that the advantages of emissions trading – i.e. the political advantages at both domestic and international levels – would prevail over taxes.

4.1.3 Long term and short term objectives

This area is the topic of considerable research efforts and a full review would be beyond the scope of this paper (see, e.g., Philibert et al., 2003; Pershing & Tudela, 2003; Corfee-Morlot & Höhne, 2003). This examination simply aims to show that the various ways considered below to reduce cost uncertainty in using emissions trading and short-term quantified objectives by no means contradict or impede the achievement of the ultimate objective of the Convention.

The ultimate objective is to stabilise greenhouse gas concentrations in the atmosphere “*at a level that would prevent dangerous anthropogenic interference with the climate system*” within a time-frame “*sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner*”. As noted earlier, the timescale over which emissions reductions are achieved will determine the level of concentrations eventually stabilised.

Indeed abatement costs must be part of any decision on these levels, and the discussion on what may be “dangerous levels” cannot be disconnected from the abatement cost issue. If it were not the case, one would simply decide to return without delay to pre-industrial levels, since there is no guarantee that even current levels are not “dangerous”. Climate change is already occurring and already detrimental for some species and human communities. But this would perhaps not *“enable economic development to proceed in a sustainable manner”.*

However, the inertia in climate systems calls for early action, while the inertia in the technical systems constrains the level of action. In that context, how to be sure to engage sufficient action if the objective remains undetermined? One way out of this dilemma might be to aim at low levels of emissions, while making full achievement conditional on actual costs (IEA, 2002). Indeed, price capping mechanisms (price caps, non-binding targets and, to some extent, dynamic targets) allow this:

- Short-term ambitious targets are adopted, but might be exceeded if they are too costly to be fully achieved.

- Similarly, one could adopt indicative long-term objectives, subject to periodic revisions.
- If price caps have been used and short-term targets are not reached, revisions would either augment the long-term objective in order to take into account higher abatement costs, or maintain it and augment the level of price caps – depending on the scientific knowledge at the time (Philibert & Criqui, 2003)

In other words, price capping mechanisms do not undermine the achievement of a long term objective that cost and benefit uncertainties do not allow to define precisely. On the contrary they might prove capable of performing "en route" the cost-benefit analysis that would be desirable but cannot be performed today.

4.1.4 Institutional capabilities

The need for a global regime will imply engaging, amongst others, developing countries. One important question is their institutional capabilities to handle it – and the risks associated with possibly insufficient capacities. Even if risks for economic development are removed with non-binding targets, or alleviated with dynamic targets and/or sector-wide targets (options discussed in 4.2), this challenge is likely to remain, though possibly in slightly different terms.

Willems & Baumert (2003) discuss extensively the institutional capability needs associated with undertaking various policies and measures and various types of commitments, including emissions trading. According to Greenspan Bell (2003), if transparency, accurate monitoring, a working legal system, and realistic incentives to trade are scarce in transitioning economies, *"the problems run much deeper in the developing world"*. There are fewer people with the necessary skills and experience to implement these sophisticated programmes, the available talent is generally concentrated in capitals rather than field posts, monitoring equipment is in short supply, even baseline data are unreliable, and informal and even institutionalised corruption is rampant. Greenspan Bell wonders if it is realistic *"to expect that countries only beginning the process of environmental protection can start with the most difficult environmental instruments"*.

Similarly, Baumert et al. (2003) remind us that in trading systems "*achieving positive results requires competitive markets and other conditions that, in reality, may prove elusive, especially within the confines of international treaty law where participation and compliance cannot be assured."* They also note that *"if cross-border financial flows from trading turn out to be significant, then it does not necessarily follow that revenues would be used domestically for socially beneficial purposes, such as poverty alleviation or helping countries adapt to adverse climate impacts."*

There are no easy answers to such questions. The need for a working legal system to back emissions trading seems obvious. On the other hand, the cost-effectiveness of emissions trading would exert a lower pressure on the compliance regime of any environmental policy. By equalising at a reasonable level the marginal cost of emissions, it would increase the chances that the costs to comply are lower than the costs (and risks) to bribe the authorities.

According to Willems & Baumert (2003), the institutional needs for emissions trading might differ with various options for future targets: "*Fixed, legally-binding, comprehensive targets certainly put the strongest pressure on the domestic policy setting to create the institutional conditions to meet them. Dynamic targets or targets with price caps somewhat reduce these capacity needs by reducing a source of uncertainty inherent in achieving a fixed target. Yet, they have new features which may create additional institutional capacity requirements. Sectoral targets and non-binding targets unequivocally reduce some of the institutional needs, by, respectively, reducing the scope of the target and limiting capacities needed to make sure the target is met"*.

There is a clear case for capacity building being of focus of international collaboration with economies in transition and developing countries. Capacity building should address the wider set of institutional issues associated with greenhouse emissions management, including but not limited to implementation of emissions trading.

4.2 Dealing with uncertainties

As suggested above, emissions trading in the climate change case has strong policy advantages over carbon taxes, but may have lower overall economic performance (i.e. lower expected net benefits) due to uncertain abatement costs.

There are several ways to alleviate this problem and give an emissions trading regime the flexibility of adjusting the overall amount of emission reductions to the actual costs. These are: time flexibility (banking and borrowing); dynamic targets; and price caps. In addition, as the reluctance of developing countries to adopt any binding commitment might be interpreted as a refusal to subject their economic development to any economic risk arising from such commitment, emissions trading with non-binding targets for developing countries is another way to mitigate cost uncertainty, as is sector-wide emissions trading.

4.2.1 Time flexibility: banking and borrowing

As noted by Ellerman et al. (2003), the cumulative effect of greenhouse gases and their long duration in the atmosphere means that the timing of emissions reductions with a control programme will not have a significant effect on atmospheric concentrations and on climate. Time flexibility may not be detrimental to the environmental purpose of a greenhouse gas trading regime. And it has important economic advantages demonstrated by both past experiences and theoretical considerations. In past or existing emissions trading schemes, banking has proven an effective tool to smooth price variations and avoid risk of non-compliance. Its absence in the RECLAIM case led to some excess emissions. Analyses suggest much lower expected costs if time flexibility helps adjust any short-term amount of abatement to the reality of abatement costs.

The Kyoto Protocol already contains two types of time flexibilities: the five-year duration of the first commitment period, useful to smooth year to year climate or economic variability in some trends underlying unabated emission trends; and the banking provisions of its article 3.13.

Full time flexibility, however, would require borrowing as well as banking to operate smoothly and really allow emissions trading to adjust to actual costs. While borrowing has been strongly advocated in the past by some environmental NGOs, it remains only cautiously backed by some analysts (see, e.g., Jacoby & Ellerman, 2004). The obvious risk with borrowing is that the environmental objective would be undermined if a source could borrow indefinitely from its future allocations and never pay back its environmental debt. This risk is presumably more severe when compliance mechanisms are weak, as is most likely the case in the international arena when participants are sovereign countries.

In the Kyoto Protocol, Parties have explicitly rejected borrowing, although the penalty system adopted in case of non-compliance can be compared with a form of borrowing with an automatic increase in cost equivalent to 30% of the borrowed unit. But a Party cannot declare that it will borrow from its future commitment (Baron & Bygrave, 2002)

However, in a recent paper, Newell et al. (2003) investigate several methods to use banking and borrowing to manage permit prices – while avoiding the money transfers from entities to governments (or from governments to an international bodies) that could take place with a price cap. Most of these methods would basically allow the regulator to modify the allocation or the true “value” (in tonnes) of the permits, or simply the right to trade them (under the “adjustable permit reserves” option) either permanently or at regular intervals. The political economy benefits of these options remained to be proven, especially in the context of an international agreement.

4.2.2 Dynamic targets

Dynamic targets are indexed according to an agreed variable, for example on the actual economic growth. Assigned amounts would be adopted in advance and based on some expectation – in this example relative to GDP growth, at a country level, or to some metrics of output, at the entity level. Then, if the economic growth were more or less than expected, these assigned amounts would be revised upward or downward. Dynamic targets would thus reduce the cost uncertainty that stems from uncertain emission trends – i.e. the uncertainty on the levels of emission cuts needed to reach a fixed target. Dynamic targets, however, are much less likely to address uncertainty about the costs of future abatement options or technologies.

Dynamic targets could, in principle, be an option for both developed and developing countries, since they allow for full differentiation – either through varying assigned amounts or indexation formulas (Philibert et al., 2002). So-called “intensity targets” (defined as a ratio of greenhouse gas emissions to GDP) represent a particular form of dynamic targets. However, the indexation of assigned amounts could take various forms, and other variables (e.g., population, exports, energy consumption, etc.) could also enter the picture and take into account, e.g., the role of agriculture in non-CO_2 GHG or the carbon intensity of energy consumption.

Intensity targets raise a number of concerns. Some concerns are linked to the risks of either “double pain” in case of unexpected economic recessions or too generous allocation in the opposite case (Müller et al., 2002). Others stem from the fact that it remains unclear if uncertainty on future intensity levels is much less than that on future unabated emission trends (Dudek & Golub, 2003). Concerns have also been expressed that trading with intensity targets, i.e. uncertain assigned amounts, would be more difficult (Moor, 2002). Concrete experience with relative targets at firms’ level is too limited thus far to provide useful insight in this debate. Another concern might be that of intensity targets inadequately accounting for large fluctuations in GDP, to which developing countries are particularly prone. In case of generous allocations in order to achieve wide participation, rapid growth in GDP may lead to significant increases in emissions.

However, it might be that well-shaped dynamic targets could solve or alleviate most of these concerns. Ellerman and Wing (2003) suggest a simple and general formula for a “growth-indexed emission limit” that combines a fixed and an intensity target. The degree of indexing, i.e. the relative weights of the two opposite forms, can take any value between zero (pure fixed targets) and one (pure intensity targets). More analysis would be needed to find if there is a range of indexing values really capable of reducing uncertainty.

Another difficulty arises from measuring GDP and growth rates (or other variables used in the indexation formula). In developing countries in particular, such measurement is often difficult and sometimes controversial. This might be another area for further investigation.

Critics have also suggested that intensity targets would need to be based on an unrealistic pace of carbon intensity improvements to achieve stabilization of GHG concentrations at acceptable levels (Müller et al., 2002). Implicitly, this suggests that countries could adopt stringent-enough fixed targets that would be only achievable by constraining their economic growth. This seems even more unrealistic. Countries are, on the contrary, more likely to adopt sufficiently ambitious targets if their economic development is somehow protected by a mechanism to keep costs under control if the technical change to carbon-lean technologies turn out to be slower – and abatement costs higher – than expected.

4.2.3 Safety Valve or price caps

Permit systems can be designed to deal with the price-spike problem. Safety-valve mechanisms involving a maximum price on permits could eliminate the severe economic damage that could result from a dramatic, if temporary, change in circumstances such as occurred in the California electricity deregulation case. The "safety valve" or price cap is a possible addition to a cap-and-trade system of emissions regulation whereby the authority offers to sell permits in unlimited amount at a pre-set price. In this way, the cost of meeting the cap can be limited.

The safety valve was originally proposed in the United States as a way to control perceived high costs of meeting the Kyoto Protocol, and possibly as a way to shift the focus of policy from the quantity targets of the Protocol to emissions price. Some see its application being limited to the short term. For example, Jacoby & Ellerman (2004) write that *"It may be desirable to adopt a safety valve in conjunction with a quantity limit on GHGs, particularly if there is no other way to tame an over-ambitious target. But application of the safety valve proposal will naturally raise objections concerning how these inconsistent components are to be harmonised"*.

However, economic theory suggests that hybrid instruments combining prices and quantities are likely to perform more efficiently than either price or quantity instruments alone, when abatement costs are uncertain, as shown by Robert and Spence (1976) after Baumol & Oates (1971), much before tradable permits were first conceived. As the international community engages in abatement policies, abatement costs will progressively reveal themselves and uncertainty will shrink. At any time in the foreseeable future, however, large uncertainties will persist on abatement costs linked to more ambitious objectives set years or decades before their achievement.

A complete "hybrid" instrument would involve a quantity and two prices: a floor price (below which the regulator would subsidise more abatement) and a ceiling price or price cap. If the floor price is absent, as might be the case in an international regime, it would be necessary to make the quantified target more ambitious than otherwise. As Aldy et al. (2001) put it, *"the safety valve is* not *intended to set an inefficiently low carbon price over time. Indeed, the safety valve may allow a* higher *price of carbon than would otherwise be the case, because it provides assurance that the costs will not exceed that level. (...) The cost insurance provided by the safety valve could thus have environmental benefits, once the political economy of the emission reduction effort is taken into account"*.

The concept of the price cap may take two different forms in an international agreement. In the first one, economic agents or countries, according to the global result of their domestic policy, buy these permits from an international body. In the second, economic agents within countries buy these permits from their own government. In the first case, countries would have to accept the possibility of some international transfers, on top of trading. In the second, countries would have to demonstrate that all their domestic sources or sectors really face an abatement cost that is at least equal to the price cap. It would thus seem necessary to cover all agents with a comprehensive tradable permit scheme, such as the hybrid upstream downstream mentioned above, or to complement a trading regime with a carbon tax set at the price cap level.

Sceptics have argued that agreeing among industrialised countries on a single price cap would be *"a nightmare"* (Mueller et al., 2002). However, such an agreement neither appears that impossible – nor that necessary.

- Not that impossible, because negotiations of a single price cap would not be about accepting the same marginal costs, as would be an agreement on a tax level. It is even less an agreement about the same level of efforts for this would be defined by the size of the assigned amount with respect to the unabated emission trends. Under a single price cap system, countries can still have different levels of efforts, and appropriately differentiated assigned amounts.

- Not that necessary, for if there are several price caps, trading remains possible (provided overselling is prevented). Only countries with actual emissions below their original assigned amounts should be net sellers. Buying supplementary permits should be made incompatible with being net sellers. If the price cap is implemented at domestic level, only national entities would be allowed to buy supplementary permits, and only in proportion to their emissions above the target.

However, having many different levels of price caps in a single regime augments the risk of efficiency losses. A possible compromise between efficiency and political realities might be to institute three price cap levels in an international GHG emissions trading regime. The highest level would be for industrialised countries. A lower level would be for most-advanced developing countries and some economies in transition. A very low or zero level – which could then be assimilated to a non-binding target as discussed below – would be for low-income developing countries (Philibert & Criqui, 2003).

If costs turn out to be higher than expected, supplementary permits would thus be delivered either by governments or by some international entity. The question of how to use the unpredictable revenues then arises. Options include: financing more adaptation to compensate for higher emissions; or financing more research and development to help bring abatement costs down the price cap level.

4.2.4 Non-binding targets

The conventional wisdom takes for granted that emissions need to be capped for emissions trading to take place. However, there is no need for all agents to be potential buyers, and it is possible that some be only potential sellers. They would thus have non-binding (though negotiated and not unilaterally shaped) targets. Sales would occur if (and only if) actual emissions are less than the targets (Philibert, 2000).

Non-binding targets offer another way to reduce cost uncertainty (although these types of targets would not deliver environmental certainty). This option is essentially similar to the price cap option, in which the price-cap is set to zero. By alleviating cost concerns it may allow the adoption of relatively more stringent targets. This may help eliminate or reduce the need to allocate some excess allowances to countries willing to take on new commitments.

There are different ways to ensure that countries only sell emission allowances that exceed the coverage of their actual emissions. The most attractive may be to make countries responsible for buying back any selling beyond what they have left at the end of the commitment period (Philibert & Pershing, 2001). A commitment period reserve similar to that instituted by the Marrakech Accords would also limit the possible size of inadvertent mistakes.

The primary failing of the non-binding target option lies in the limited certainty it provides on environmental benefits. As far as developing countries are concerned, however, the possible environmental benefits may be higher than with fixed, binding targets, as these are likely to be rejected, or only accepted if they provide excess allowances. Non-binding targets may thus be a better choice (Philibert et al., 2003). Nevertheless, the risk remains that important deviations of the economy from its expected trends – not uncommon in developing economies - create either a large amount of surplus allowances or large deficits. Surplus allowances would make participation in the trading regime less environmentally-effective; large deficits would make participation unlikely if not impossible. These risks might be reduced with well-shaped dynamic – but still non-binding – targets.

Emissions trading with non-binding targets would be similar to the structure of the Clean Development Mechanism. The latter is also non-binding: if a project under the CDM drives more emissions than the agreed baseline, rather than less, neither the host country nor the investor would have to compensate for this increase. But while the certified emissions reductions in the CDM should be calculated against an objective baseline ("what would have happened otherwise"), non-binding targets could be set differently – although the expected unabated emissions trend might provide a useful starting point for the negotiations.

The non-binding character of this target, however, may make it possible to set the level of the target at a more stringent level than might have been the case with binding, fixed targets – particularly as it alleviates concerns about economic development. For example, the establishment of the target level may be set to deduce the potential for "win-win" or "no-cost" options from the baseline, as suggested by Philibert & Pershing (2001). Viguier (2003) goes a step further in considering a wider range of options that would still leave developing countries better off in participating to emissions trading (not taking into account the climate benefits). He suggests that this condition is met provided the benefits accruing from emissions trading below the target (producer's surplus) are larger than the costs of the domestic reductions to achieving the target.

4.2.5 Sector-wide targets

The twin concepts of sector-wide CDM projects and/or sector-wide quantified objectives seem to be gaining wider recognition within the climate expert community (Philibert & Pershing, 2001; Baumert et al., 2002; Ellis et al., 2004). Sector-wide targets might be chosen for various reasons. A developing country, for example, might wish to complement the Clean Development Mechanism by targets in sectors not readily addressed with project activities, such as household and transport. Alternatively, sector targets might be adopted for industry sector(s), while leaving emissions more directly linked to people's end-use consumption unregulated. For example, a developing country government may wish to secure the switch from dirty and inefficient uses of biomass to cleaner and more efficient uses of fossil fuels in households to improve in-door air quality and people's health. Sector-wide targets might be fixed or dynamic, binding or non-binding. They may also be established in such a way as to allow emissions trading (Philibert et al., 2003)

With sector-wide CDM projects, countries might choose to expand from a specific "project" under the CDM to a broader policy covering an entire sector. Effects of specific policy actions would be judged against a reference scenario – and if they could be determined to generate quantifiable reductions below what would happen without the policy, they could be credited. As with other CDM projects, there would be no obligation to act. It has been suggested that sector-wide CDM projects could also direct the credits to some specific investments into the sector (Chung, 2003); however the concrete mechanisms to do so remain to be considered.

One alternative would be to establish sector-wide domestic emissions trading schemes in developing countries. Market actors would thus be entitled to trade on the global market. If the government is concerned that a sector-wide target may entail unexpectedly high costs – it could suggest to the international community non-binding and/or dynamic sector-wide targets, or to institute a (presumably low) price cap. In case of non-binding sector-wide targets, of course, there would be no trade within the domestic scheme as there would be no buyers. All trades would thus come from buyers in countries with binding caps.

5. CONCLUSION

A quarter of a century after their invention, emissions trading schemes have gained extensive recognition and significant experience – mostly in air pollution applications. As far as greenhouse gases are concerned, the experience is much more recent. Since each existing or past emissions trading system has its own architecture and design, lessons learnt – apart from the economic theory - cannot be take as a generality.

Cost-effectiveness and environmental effectiveness are mutually reinforcing. Emissions trading gives flexibility to governments to deal with vested interests, and allows governments and negotiators to focus on the acceptability of the initial allocation in both domestic and international contexts. Emission trading schemes to date have only partial coverage of emissions (usually excluding household and transport emissions), and no regimes have tested the upstream approach or the upstream/downstream hybrid trading schemes. Emissions trading is therefore likely to be part of a broader policy mix to control emissions from the whole economy. Nevertheless, an emission trading scheme is potentially one of the most powerful tools to build an effective global response to climate change – though institutional requirements might impede its use in various countries.

Extending participation and coverage in emission trading schemes allows a reduction of overall costs of achieving the emissions target over the long term. However, several barriers to countries taking on climate commitments include cost uncertainty and institutional capacities.

This paper reviews various instruments that can potentially increase the flexibility of emissions trading and reduce its cost uncertainty, encouraging other countries – and especially developing countries – to participate in the trading regime. This paper has not engaged in a discussion about allocation amongst countries, for it is precisely a property of emissions trading to disentangle the economics of actual emissions abatement and the politics of the initial allocation. Technical work in this area could be useful, however, and might be undertaken in the future.

The building of a progressively global regime can result from future agreements within the UNFCCC or from a “bottom-up” construction by linking several trading schemes, or a bit of both. Some of the technical issues of linking domestic emission trading schemes are dealt in a parallel paper (Blyth and Bosi, 2004). Specific linkages issues of emission trading schemes with project-based mechanisms are also dealt with in another paper (Bygrave and Bosi, 2004).

However, the fact that several regimes could be linked does not necessarily mean that they will be linked. While the gain in cost-effectiveness from linkages is clear, countries may want to ensure that in this construction their partner countries undertake a level of efforts that they find acceptable from an equity perspective, including considerations about competitiveness. Mutual recognition will be needed, both on the form of the scheme (binding/non-binding, fixed/dynamic, level of possible price cap, sector coverage), as well as the implicit ambition of quantified objectives.

REFERENCES

Aldy J.E., Peter R. Orszag & Joseph E. Stiglitz, 2001, *Climate Change: An Agenda for Global Collective Action*¸ Prepared for the conference on “The Timing of Climate Change Policies”, Pew Center on Global Climate Change, October

Aldy, J.E., J. Ashton, R. Baron, D. Bodansky, S. Charnovitz, E. Diringer, T.C. Heller, J. Pershing, P.R. Shukla, L. Tubiana, F. Tudela, X. Wang, 2003, *Beyond Kyoto – Advancing the international effort against climate change*, Pew Center on Global Climate Change, Arlington, VA

Baron, R. & S. Bygrave, 2002, *Towards International Emissions Trading: Design Implications for Linkages*, OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT(2002)5

Barrett, S., M. Grubb, K. Roland, A. Rose, R. L. Sandor, & T. H. Tietenberg, 1992, *Combating Global Warming: study on a global system of tradeable carbon emission entitlement*, UNCTAD/RDP/DFP/1, Geneva

Baumert et al., 2002, *Building on the Kyoto Protocol: Options for Protecting the Climate*, World Resource Institute, Washington D.C.

Baumert, K., J.F. Perkaus & N. Kete, 2003, Great expectations: can international emissions trading deliver an equitable climate regime? *Climate Policy*, **3** (2): 107-187

Baumol, W.J., 1972, On taxation and the Control of Externalities, *American Economic Review*, **LXII**(3), June: 307-322

Baumol, W.J. & W.E. Oates, 1971, The Use of Standards and Prices for Protection of the Environment, *Swedish Journal of Economics*, vol.73, March, 42-54

Blyth, W., & M. Bosi, 2004, *Linking non-EU Domestic Emissions Trading Schemes with the EU Emissions Trading Scheme*, Draft Paper, OECD/IEA Project for the Annex I Expert Group on the UNFCCC

Bohm, P., 1999, *International Greenhouse Gas Emissions Trading – with special reference to the Kyoto Protocol*, Nordic Council of Ministers

Bovenberg, L., & L. Goulder,2001, Neutralising the Adverse Industry Impacts of CO_2 Abatement Policies: What does it Cost?, in C. Carraro and G.E. Metcalf (eds.), *Behavioral and Distributional Effects of Environmental Policy*, University of Chicago Press.

Bygrave, S. & M. Bosi, 2004, *Linking Project-based Mechanisms with Domestic Greenhouse Gas Emissions Trading Schemes*, OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT(2004)5

Coase, R.H., 1960, The Problem of Social Cost, *Journal of Law and Economics*, **III**, October: 1-44

Chung, R.-K., 2003, *CDM linked Voluntary Dynamic Target*, presentation at the CCAP’s Dialogues on Future Actions and Clean Development Mechanism, Jeju Island, KR, October

Dales, J. H., 1968, *Pollution, Property and Prices*. Toronto, University of Toronto Press.

De Coninck, H.& N. Van der Linden, 2003, *An overview of carbon transactions – general characteristics and specific particularities*, Energy Research Center of the Netherlands, Petten, NL

DEFRA, 2003, *Commentary on preliminary 1st year results and 2002 transaction log,* UK Department for Environment, Food and Rural Affairs, London, UK

Depledge, J., 2000, *Tracing the Origins of the Kyoto Protocol: An Article-by-Article Textual History*, Technical Paper, FCCP/TP/2000/2, UNFCCC, November

Diringer, E., 2002, *Two Scenarios: Linking U.S. and International Climate Change Efforts*, IETA/IEA/EPRI Brainstorming Session on Convergence of GHG Regimes and Linking Trading Schemes, Montreal, April

Dudek, D. & A. Golub, 2003, "Intensity" targets: pathway or roadblock to preventing climate change while enhancing economic growth? *Climate Policy* **3S2:** S21-S28

Edmonds, J., Wise, M. & D. W. Barns, 1995, Carbon coalitions, *Energy Policy*, vol. 23, n°4/5, April/May

Edmonds, J. & M. Scott, 1999, *International Emissions Trading and Global Climate Change*, PEW Center on Global Climate Change, Arlington, V.A.

Ellerman, D. A., 2003, *Ex Post Evaluation of Tradable Permits: The U.S. SO2 Cap-and-Trade Program,* MIT CEEPR Working Paper 2003-003, Massachusetts Institute of Technology, MA

Ellerman, D.A., P. L. Joskow & D. Harrison Jr, 2003, *Emissions trading in the U.S., Experience, Lessons, and Considerations for Greenhouse Gases*, Pew Center on Global Climate Change, Arlington, V.A.

Ellerman, D.A. & I.S. Wing, 2003, Absolute versus intensity-based emission caps, *Climate Policy*, **3S2**: S7-S20

Ellis, J., H. Winkler & J. Corfee Morlot, 2004, *Taking Stock of Progress under the CDM*, OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT(2004)4

Environmental Finance, 2003, *Oil Firms Learn Trading Lessons*, Environmental Finance Emissions Trading, February

Environmental Resources Management, 2002, *GETS 3 – Greenhouse Gas and Energy Trading Simulations*, Final Report for Eurelectric, the Union of the Electricity Industry, March

Grubb, M. C. Vrolijk & D. Brack, 1999, *The Kyoto Protocol, A Guide and Assessment*, The Royal Institute of International Affairs, London

Haites, E. & F. Mullins, 2001, *Linking Domestic and Industry Greenhouse Gas Emission Trading Systems*, report prepared for Electric Power Research Institute, International Energy Agency and International Emissions Trading Association, October

Hargrave, T., 2000, *An Upstream/Downstream Hybrid Approach to Greenhouse Gas Emissions Trading,* Center for Clean Air Policy, Washington, June

Harrison, D. Jr, 1999, Tradable permits for air pollution control: the US experience, in OECD, *Implementing Domestic Tradable Permits for Environmental Protection*, OECD, Paris

Harrison, D. & Radov D., 2002, *Evaluation of Alternative Initial Allocation Mechanisms in a European Union Greenhouse Gas Emissions Allowance Trading Scheme*, Report by National Economic Research Associates prepared for DG Environment, European Commission, March

OECD, 1992, *Climate Change: Designing a Tradeable Permit System*, OECD, Paris

IEA, 2001, *International Emissions Trading – From Concept to Reality*, OECD/IEA, Paris

IEA, 2002, *Beyond Kyoto – Energy Dynamics and Climate Stabilisation*, OECD/IEA, Paris

Jacoby, H.D., & D.A. Ellerman, 2004, The safety valve and climate policy, *Energy Policy* 32: 481491

Jones, B., 2002, *Emerging State and Regional GHG Emission Trading Drivers*, M.J. Bradley & Associates, Inc., EUEC

Johnstone, N., 2003, Efficient and Effective Use of Tradeable Permits in Combination with other Policy Instruments, OECD

Kessels, J. & W. Hennessy, 2004, *The Impact of Emissions Trading on the Coal Industry* (draft report), CRL Energy, IEA Clean Coal Centre

KMPG, 2002, *Trading for a better climate – Feasibility of a national system for CO_2 emission trading*, Summary of Final Recommendations of the Dutch CO_2 Trading Commission, January

Lecocq, F. & R. Crassous, 2003, *International climate regime beyond 2012 – Are quota allocation rules robust to uncertainty ?* Working paper, The World Bank, Washington D.C.,

Moor, A.P.G. de, M.M. Berk, M.G.J. den Elzen & D.P. van Vuuren, 2002, *Evaluating the Bush Climate Change Initiative*, RIVM rapport 728001019/2002, RIVM, Bilthoven, NL

Müller, B., A. Michaelowa & C. Vroljik, 2002, *Rejecting Kyoto, A study of proposed alternatives to the Kyoto Protocol*, Climate Strategies, http://www.wolfson.ox.ac.uk/~mueller/rk2ed.pdf

Najam A., S. Huq & Y. Sokona, 2003, Climate negotiations beyond Kyoto: developing countries concerns and interests, *Climate Policy* 3: 221-231

Newell, R.G. & W.A. Pizer, 2000, *Regulating Stock Externalities under Uncertainty*, Discussion Paper 99-10, Resources for the Future, Washington DC, February

Newell, R., W. Pizer & Z. J. Zhang, 2003, *Managing Permit Markets to Stabilise Prices* Discussion Paper n°03-34, Resources for the Future, Washington DC, June

Niizawa, H., T. Saijo and A. Yasumoto, 2003: *Proposal of Upstream Emissions Trading in Japan*, OECD Global Forum on Sustainable Development: Emissions Trading, Paris.

OECD, 1999a, *Implementing Domestic Tradable Permits for Environmental Protection*, OECD, Paris

OECD, 1999b, *Action Against Climate Change*, OECD, Paris

OECD, 2001, *Domestic Transferable Permits for Environmental Management: Design and Implementation*, OECD, Paris

OECD, 2002, *Implementing Domestic Tradeable Permits: Recent Developments and future Challenges*, OECD, Paris

OECD/IEA (2003), *Policies to Reduce Greenhouse Gas Emissions in Industry – Successful Approaches and Lessons Learned.* Workshop Report, OECD and IEA Information Paper, Paris

Parry, I.W.H. & M.A. Bento, 1999, *Tax Deductions, Environmental Policy, and the "Double Dividend" Hypothesis*, Working Paper, The World Bank, Washington D.C., May

Pedersen, S., 2002, *Danish CO2 cap & trade scheme: Function and Experiences*, the SERC workshop Tokyo 3 December 2002

Pershing, J. & F. Tudela, 2003, A Long-Term Target: Framing the Climate Effort, in *Beyond Kyoto – Advancing the international effort against climate change*, Pew Center on Global Climate Change, Arlington, V.A.

Peterson, S., 2003, *Monitoring, Accounting and Enforcement in Emissions Trading Regimes*, OECD Global Forum on Sustainable Development: Emissions Trading, March

Philibert, C., 2000, How could emissions trading benefit developing countries, *Energy Policy* vol. 28, n°13, November

Philibert, C., 2002a, *Evolution of Mitigation Commitments: Certainty versus stringency,* Revised Draft Note, OECD/IEA Project for the AIXG, Paris, March

Philibert, C., 2002b, *Evolution of Mitigation Commitments: Fixed targets versus more flexible architectures*, Revised Draft Note, OECD/IEA Project for the AIXG, Paris, March

Philibert, C., 2003, *Technology Innovation, Development and Diffusion*, OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT(2003)4

Philibert, C., 2004, *International Energy Technology Cooperation and Climate Change Mitigation*, OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT(2004)1

Philibert, C. & P. Criqui, 2003, *Capping emissions and costs*, paper presented at the RFF-IFRI workshop "How to make progress post-Kyoto?", Paris, 19 March

Philibert, C & J. Pershing, 2001, Considering the options: climate targets for all countries, *Climate Policy* **1**: 211-227

Philibert, C., J. Pershing, J. Corfee-Morlot & S. Willems, 2003, *Evolution of Mitigation Commitments: Some Key Issues,* OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT(2003)3

Pizer, W.A., 1997, *Price vs. Quantities Revisited: The Case of Climate Change*, Discussion Paper 98-02, Resources for the Future, Washington, DC

Pizer, W.A, 1999, *Choosing Price or Quantity Controls for Greenhouse Gases*, Climate Issues Brief No. 17, Resources for the Future, Washington, DC

Pizer, W.A., 2002, Combining Price and Quantity Control to Mitigate Global Climate Change, *Journal of Public Economics*, n°85: 409-434

Pizer, W.A., 2003, *Climate Change Catastrophes*, Discussion Paper 03-31, Resources for the Future, Washington D.C.

Reinaud, J., 2003, *Emissions Trading and its Possible Impacts on Investment Decisions in the Power Sector*, IEA Information Paper, IEA, Paris

Roberts, M.J. & M. Spence, 1976, Uncertainty and the Choice of Pollution Control Instruments, *Journal of Public Economics*, vol.5, April/May

Rosenzweig, R. & J. Janssen, 2002, *The Emerging International Greenhouse Gas Market*, PEW Center on Global Climate Change.

Smith, A. & Ross, M., 2002, *Allowance Allocation: Who Wins and Loses under a Carbon Dioxide Control Program*, Charles River Associates, February

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

Sorrel, S. & J. Sijm, 2003, Carbon Trading in the Policy Mix, *Oxford Review of Economic Policy*, vol.19 n°3

Stavins, R.N., 2003, *Market-Based Environmental Policies: What Can We Learn from U.S. Experience (and Related Research)?* Discussion Paper 03-43, Resources for the Future, Washington D.C.

Tietenberg, T., 1999, *Tradable Permit Approaches to Pollution Control: Faustian Bargain or Paradise Regained?*, working paper, available at http://www.colby.edu/personal/t/thtieten/

Tietenberg, T., 2002, The Tradable Permits Approach to Protecting the Commons: What Have We Learned? *The Drama of the Commons*, E. Ostrom, T. Dietz, N. Dolsak et al. Washington, DC, National Academy Press: 197-232.

Tietenberg, T, 2003, The Tradable Permits Approach to Protecting the Commons: Lessons for Climate Change, *Oxford Review of Economic Policy*, vol.19 n°3: 400-419

Viguier, L., *2003, Exploring new tools: the T&B approach*, paper presented at the RFF-IFRI workshop "How to make progress post-Kyoto?", Paris, 19 March

United States Environmental Protection Agency, 2003, *Tools of the Trade: A Guide to Designing and Operating a Cap and Trade Programme for Pollution Control*, EPA430-B-03-002, June

Vis, P., 2001, *10 points on linking national trading schemes*, Notes for IETA side event on 19 July 2001 at COP6 part 2

Weitzman, M. L., 1974, Prices *vs.* Quantities, *Review of Economic Studies*, vol.41, October

Willems, S. & K. Baumert, 2003, *Climate Actions and Institutional Capacity: Current and Future Challenge*, OECD and IEA Information Paper, COM/ENV/EPOC/IEA/SLT(2003)**X**

Yang, J & J. Schreifels, *Implementing SO_2 emissions in China*, OECD Forum on Sustainable Development/ CATEP Forum, OECD, Paris, March