INTERNATIONAL ENERGY AGENCY

International Emission Trading

From Concept to Reality



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It carries out a comprehensive programme of energy co-operation among twenty-five* of the OECD's thirty Member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions;
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations;
- To operate a permanent information system on the international oil market;
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use;
- To assist in the integration of environmental and energy policies.

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Foreword

Since its adoption in the Kyoto Protocol text, emission trading has been advanced as one of the primary tools for international co-operation to reduce emissions of greenhouse gases. The contribution of emission trading to international climate policy will depend on the rules that will govern the international emissions market. The IEA has actively contributed to this discussion with its work under the aegis of the OECD/IEA project for the Annex I Expert Group on the United Nations Framework Convention on Climate Change. Over the last few years, the IEA has also undertaken energy modelling and market experiments to explore economic and practical questions related to this innovative mechanism.

The present book contains material from this large body of work, updated to reflect recent developments. It offers a broad assessment of international emission trading at a time when such an assessment is most needed by governments, the private sector and non-governmental organisations alike. In particular, it brings to the table new estimates of how the emissions market is likely to evolve, now that the United States has pulled out of the Kyoto Protocol.

Without prejudging countries' climate change policy choices, the goal of this book is to clarify what can be expected from international emission trading in the energy sector and in other activities as well.

Robert Priddle
IEA Executive Director

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Executive Summary

Emission trading – specifically the trading of greenhouse gas emissions on a still-to-be-created international market – is an essential process in the world effort to combat unwanted climate change. It is also poorly understood. This book seeks to define, analyse and evaluate emission trading. To do so, it relies heavily on experience gained in national trading programmes, international negotiations and simulations organised by the electric power industry. These precedents indicate that an international emission trading regime, if properly organised, can provide a cost-effective and efficient way to address the climate change problem.

International trade in greenhouse gas emissions is specifically provided for in the 1997 Kyoto Protocol. At the heart of the Protocol is an undertaking by nearly all the industrialised countries to reduce their emissions by a fixed percentage below what they were in 1990. These reductions, which are to be made over the period 2008-2012, will be costly for many countries. Since energy production and use produce the lion's share of greenhouse gas emissions, especially CO_2, the responsibility for achieving emission reductions will fall most heavily on the energy sector. In an effort to mitigate those costs, the framers of the Protocol proposed three innovative "market mechanisms," including emission trading.

Advocates of trading argue that it allows governments and businesses to reduce emissions wherever it is cheapest to do so. Opponents contend that trading is a book keeping device which substitutes paper transactions for real world reductions.

Central to any future trading regime will be the notion of avoided emissions, negotiable units of account that represent tonnes of CO_2 in the atmosphere. Countries (and perhaps companies) will be able to trade these avoided emissions much as other commodities are traded.

Buyers will be countries in which the cost of reducing emissions is high. Sellers will be countries where the cost is less onerous – or where their Kyoto commitments are actually lower than actual emissions. Most "transition economies" – in Eastern and Central Europe and the Former Soviet Union – are in the latter category. Their economies have shrunken dramatically since 1990, and so have their greenhouse gas emissions.

Economic modelling indicates that trading can lead to cost savings of 30% to 90% for countries and companies. But so far, international emission trading exists only in theory, not in practice. A real functioning market will establish a market price for emissions. Once a price exists, those responsible for decisions on future energy investments will take that price into account when they build or replace capital stock. Indeed, the establishment of a CO_2 price will provide an incentive to develop investment strategies and to seek out appropriate technology to meet emission reduction targets at the lowest possible cost. (Real markets do not, of course, operate as smoothly as economic models, so evidence derived solely from modelling must be taken with a grain of salt.)

To supplement the information derived from models, the IEA, in close co-operation with industry and governments, has run two elaborate simulations of emission trading. The first, which was organised by power companies in Europe jointly with the Paris Bourse and the IEA, included the trading of electricity as well as of CO_2. It was a very positive experience for participants. It indicated that companies could easily take part in international emission trading. Indeed, they could transform a constraint (the obligation to cut emissions) into an asset (a new commodity to be traded alongside other commodities, from oil futures to electricity).

The second IEA simulation is reviewed here in detail. It is probably the most realistic indication of what real-world trading will look like, as it includes both governments and private entities as traders. The simulation indicated somewhat lower cost savings from trading than

did the economic models. Even so, savings were impressive – as much as 60% off the cost of curbing emissions without trading. The simulation also suggested that countries with very different domestic emission policies can conveniently trade among themselves. The participation of private companies would help trim costs still further.

Any trading system will need rules to operate. International negotiators have now defined some of the needed rules. Compliance will have to be monitored – is a given country meeting its target? Transactions will have to be systematically recorded. And there must be provisions for non-compliance. What happens when a country "sells" more emissions than it owns? How can the emergence of a "rogue" market be avoided? This book reviews and comments on all these issues.

We also consider the recent US decision to withdraw from the Kyoto Protocol and its implications for the CO_2 market. The impact on emission trading will, of course, be very large. Since the US was expected to be the largest single buyer on the market, its absence is likely to reduce the price of CO_2 dramatically. Other countries, particularly EU members and Japan, may now buy the credits cheaply and so fulfil their Kyoto commitments at a far lower price than otherwise. Sellers, on the other hand, may decide to "bank" their credits for sale later on. Our study also considers how countries outside the trading regime can become part of it.

International emission trading is full of promise. But difficult political and technical issues remain to be faced. If they are successfully resolved, the world will have gained a new and very effective way of combating climate change.



INTRODUCTION: CLIMATE CHANGE, THE ENERGY SECTOR AND EMISSION TRADING

Climate change caused by human activities threatens to affect the climate, habitat, health and economy of virtually all the countries of the world. The chair of the Intergovernmental Panel on Climate Change (IPCC) recently confirmed the influence of such emissions on the Earth's climate:

> *"The overwhelming majority of scientific experts, whilst recognizing that scientific uncertainties exist, nonetheless believe that human-induced climate change is inevitable. The question is not whether climate will change in response to human activities, but rather how much, how fast and where. It is also clear that climate change will, in many parts of the world, adversely affect socio-economic sectors, including water resources, agriculture, forestry, fisheries and human settlements, ecological systems (particularly forests and coral reefs), and human health (particularly diseases spread by insects), with developing countries being the most vulnerable."*[1]

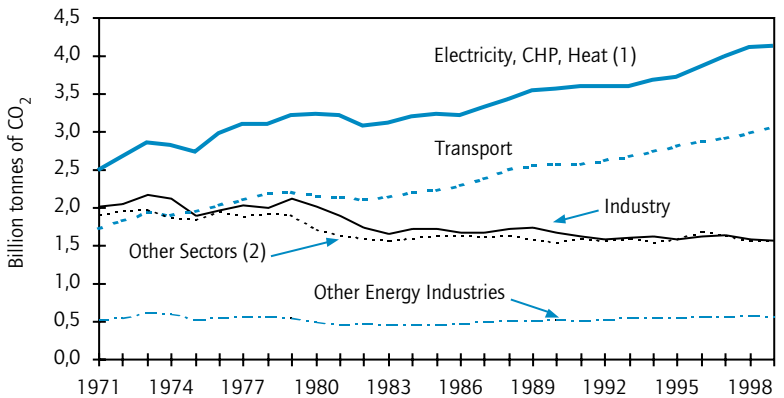
Under the United Nations Framework Convention on Climate Change (UNFCCC), more than 180 countries have recognised the need to stabilise the concentration of greenhouse gases (GHG) in the atmosphere. In 1997, the Kyoto Protocol of the UNFCCC set legally-binding GHG reduction targets for a number of industrialised countries.

1. Presentation of Robert T. Watson, Chair, Intergovernmental Panel on Climate Change at the Sixth Conference of the Parties to the UNFCCC, November 13, 2001, http://www.ipcc.ch/press/sp-cop6.htm

In industrialised countries the extraction, production and consumption of fossil fuels account for 85% of all GHG emissions.[2] Between 1990 and 1999 the energy-related CO_2 emissions of the most industrialised countries[3] increased by 10.3%. Electricity and heat generation accounted for 56% and transport for 48% of the increase (the manufacturing sector's direct emissions declined by 10%).

FIGURE 1

Industrialised Countries' CO_2 Emissions by Sector



Notes: (1) Production of electricity, combined heat and power (CHP) and heat. Includes autoproducers (self-generators of electricity and heat).
(2) Includes residential, commercial, public services and agriculture. Data cover Annex II countries to the UNFCCC (see Box 1).

Source: IEA (2001): CO_2 Emissions from Fuel Combustion, 2001 Edition: 1971-1999. International Energy Agency, Paris, France.

Most industrialised countries have reduced the energy and CO_2 intensity of their economies over the last two decades, but emissions have shown no sign of durable decline. A wide range of measures has already been taken, but more ambitious efforts are needed.[4] The IEA

2. CO_2 from fossil fuel combustion is 80 % of the total – IEA (2000) CO_2 emissions from Fuel Combustion, 2000 Edition: 1971-1998. International Energy Agency, Paris.

3. These are countries listed under Annex II of the UNFCCC, i.e. countries of the OECD as of 1992, when the Convention was agreed.

4. See, for instance, IEA (2000): Dealing with Climate Change – Policies and Measures in IEA Member Countries. IEA, Paris.

World Energy Outlook (WEO) projects a 34% increase in OECD countries' emissions by 2020 from 1990 levels. World-wide emissions are projected to grow by 73% in the same time frame. If these trends continue unabated, GHG concentrations will be more than triple what they were in pre-industrial times.

Climate stabilisation will require tremendous changes in the way energy is produced and consumed. The efforts of policy-makers are now focused on minimising the economic and social costs of changing course. Emission trading at international level was introduced in the Kyoto Protocol for that purpose. This book aims to present a clear picture of international emission trading, what it can do to promote the reduction of GHG emissions, and the conditions for its success.

The idea of international emission trading is not new. For over a decade, it has been presented as a key international policy option for tackling emissions. Former studies have shown that trading can generate very large savings in the cost of reducing emissions. Some argue that emission objectives can only be met if international emission trading is introduced.

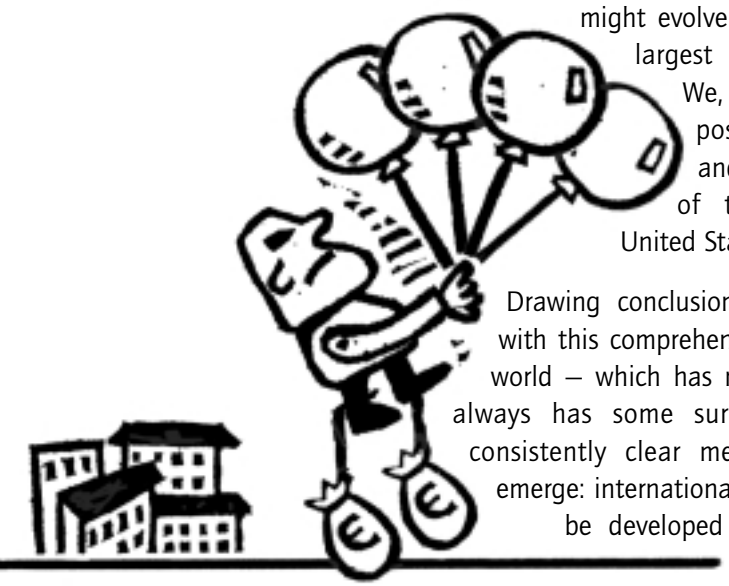
Theory, however, is not the same as practice. This book reviews the studies, and then considers the results of a practical exercise in trading by companies who are members of Eurelectric.[5]

The book goes on to consider the rules that would be needed to underpin an effective trading regime. Rules have been under active negotiation in the UNFCCC since 1997, the year of the Kyoto Protocol. Effective rules must both guarantee the environmental integrity of the system (countries must be encouraged to play fair and to meet their targets), and also ensure that the system is efficient (so that cost savings – trading's main benefit – are made). We seek to shed light on the best way forward, through a careful review of issues such as monitoring and liability, including the decisions taken in Bonn, in July 2001.

5. Eurelectric is a union of electricity companies, with membership in Europe and outside. See http://www.eurelectric.org

To test further the real world issues involved in emission trading, we then describe a market experiment organised by the IEA. The experiment demonstrates how trading will look if it is carried out in conditions as close as possible to those set by the UNFCCC negotiations. The experiment suggests that emission trading can be an extremely effective tool and can generate large savings, although not quite as large as some earlier studies suggest.

Finally, the book looks at emission trading in a global context – can it work across a much wider range of countries than just the developed world? While the UNFCCC recognises that the developed and developing countries have different responsibilities, GHG emissions can only be stabilised if all countries limit their emissions. Options for the participation of developing countries in an international emission trading system are presented and evaluated. Since March 2001, it has been imperative to consider how trading might evolve in the absence of its largest potential participant. We, therefore, consider the possible environmental and market implications of trading without the United States.



Drawing conclusions is hazardous, even with this comprehensive analysis. The real world – which has not yet been tested – always has some surprises in reserve. A consistently clear message does however emerge: international emission trading can be developed successfully. And, by providing a market signal on the cost of emissions, it can nudge the energy sector towards a more sustainable development path.

The Kyoto Protocol and Emission Trading

The Protocol (see Box 1) establishes a *legally binding obligation* for industrialised countries – referred to as Annex B hereafter – to reduce their emissions of GHG. Emissions are to be reduced in aggregate by at least 5% below 1990 levels by 2008-2012. Emission-reduction targets were differentiated to reflect national circumstances such as climate, geography, demographics, development patterns, available energy resources and, of course, subject to political negotiation. The transition economies (the FSU, Central and Eastern Europe) were set emission objectives higher than their 1997 emissions. By contrast, most OECD countries have targets that imply significant reductions (up to 30%) below their projected, business-as-usual (BAU) emissions. This is a particular challenge in that much of the energy infrastructure has a lifetime longer than the time available to make the Kyoto reductions.

Box 1

The UNFCCC and the Kyoto Protocol – Definitions

Countries which are Parties to the United Nations Framework Convention on Climate Change are divided into three categories, which reflect their respective rights and duties under the Treaty:[6]

- ***Annex I*** *Parties are industrialised countries that have committed to take the lead in reducing greenhouse gas emissions, in the light of their responsibility for past emissions. These Parties aimed to return their emissions to their 1990 levels by 2000. Annex I Parties are divided into:*

6. See http://www.unfccc.int for the legal texts of the UNFCCC and the Kyoto Protocol.

- ***Annex II*** *Parties, Members of the Organisation for Economic Co-operation and Development (OECD) as of 1992, including European countries and the European Union as such (EU), Canada, the US, Japan, Australia, New Zealand and Turkey (although Turkey never ratified the Convention);*

- *industrialised countries with economies in transition (so-called* ***EITs****), including countries from the Former Soviet Union, and from Central and Eastern Europe;*

- ***Non-Annex I*** *Parties which are, for the most part, developing countries, subject to lighter obligations, which reflect their less advanced economic development and their lower GHG emissions to date. These countries' overall emissions are now growing much faster than those of Annex I Parties.*

Under Article 3 of the Kyoto Protocol, most Annex I Parties made legally-binding obligations to limit their 2008-2012 emissions, based on 1990 emission levels. Objectives, called ***assigned amounts****, were set on a country-by-country basis in Annex B of the Treaty, but some Annex I Parties did not make such a commitment (a few countries from the former Soviet Union, but also Turkey). Only those countries with assigned amounts under Annex B can participate in emission trading. We refer to them as* ***Annex B*** *Parties or countries. The assigned amounts of Annex B countries are also expressed as assigned amount units or* ***AAUs****, the unit of exchange for emission trading.*

Not all the news is quite so bad. According to Robert Watson the IPCC chairman:[7]

> *"The good news is, however, that the majority of experts believe that significant reductions in net greenhouse gas emissions are technically feasible due to an extensive array of technologies and policy measures in the energy-supply, energy-demand and agricultural and forestry sectors."*

The issue for industrialised countries – and in due course for developing countries – is to find policies that will minimise the cost of curbing emissions. Efforts to co-ordinate specific policies across industrialised countries (e.g. a common tax on CO_2) have not succeeded because there are too many differences between them. However Kyoto created several new international policies, collectively known as "the flexibility mechanisms." These are Joint Implementation (JI), the Clean Development Mechanism (CDM) and, not least, emission trading. The mechanisms allow countries to reduce emissions where it is cheapest to do so. For each country with an emission commitment, the Kyoto objective is an "assigned amount" of emissions allowed over 2008-2012, expressed in "assigned amount units" (or AAUs). The novelty of the Kyoto Protocol is that a country may trade its AAUs to another country, if its 2008-2012 emissions are expected to be lower than its initial assigned amount. The transfers of these emission reductions may take place through all three "flexibility mechanisms":

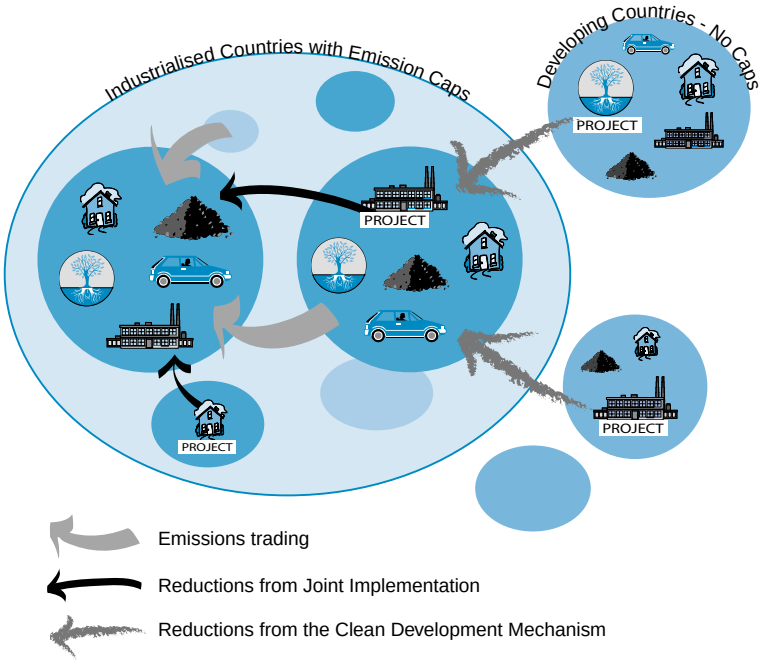
- by means of projects which reduce emissions within industrialised countries, in the case of JI;
- by projects which reduce emissions in developing countries, in the case of the CDM (which enables emission reductions achieved outside Annex I countries to be credited to these countries);
- by emission trading – explained below – which allows countries with binding commitments to trade AAUs.

7. Watson (2000), ibid.

At the end of the commitment period, a country is declared in compliance with its emission commitment if its emissions are less than or equal to its assigned amount adjusted for emission trading, JI and CDM transactions.

FIGURE 2

The Kyoto Protocol Flexibility Mechanisms



Emission Trading: What Is It and Why Is It an Attractive Policy?

How did emission trading end up on the climate change negotiating table? As the cause of climate change, GHG emissions are a form of "environmental externality", that is to say, a cost to society that does not – yet – have a monetary value attached to it. In principle, there are

two ways to put a monetary value on this cost. The first imposes a fee, or tax, on emission sources. The second starts with a limit or cap on total emissions, then translates "allowed emissions" into permits and creates a market in which these permits can be traded.

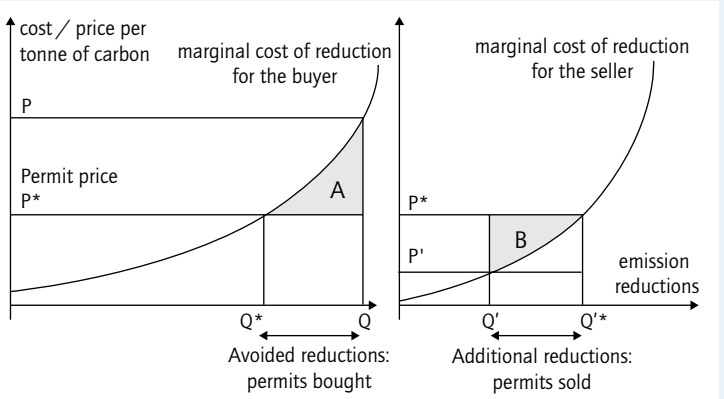
Either approach encourages sources to recognise the cost to society of their emissions and to take account of this cost in their decision making. Both give sources an incentive to reduce emissions to the point where the marginal cost of reduction equals the marginal benefit of reduction. Both also require that information be available about the marginal costs and social benefits of reductions. How much does it cost to reduce emissions by a given quantity, compared with the benefit of such reduction? There is no point in reducing emissions to a point where the cost to society exceeds the benefit. On the other hand, if the cost is less than the benefit, there is scope to reduce emissions further and to improve global welfare. The optimal reduction is therefore one where cost equals benefit. So a tax, if used, should be set to achieve this. Or, in a perfect market for tradable permits, this will be the price at which permits are traded. A key feature of both taxes and trading is that they can deliver any environmental goal – even a sub-optimal one – at least cost. The optimal cap in the case of climate change cannot be determined at present because of uncertainty about the damage caused by climate change – not to mention the distribution of impacts across regions and generations and the difficulty of aggregating them at global level. Caps on Annex I Parties were nevertheless negotiated at Kyoto and constitute the basis on which Parties can trade.

In principle, a trade takes place when a source faces higher costs to reduce its emissions than are faced by another source. The latter should be willing to reduce emissions below its own limit in order to generate additional permits for sale, at a negotiated price. Bundling the supply of and the demand for permits leads to the emergence of a public price. This price then indicates to sources whether they should reduce emissions further in order to sell permits at a profit, or acquire permits because their purchase is cheaper than the cost of internal emission reductions (Box 2). The bigger the difference in the marginal cost of

reduction among market players, the bigger the efficiency gains from trading (or the imposition of a tax).

Box 2

The Economic Logic of Tradable Permits



An emission source – on the left-hand side – needs to achieve Q reductions to comply with its emission objective. If it undertakes reductions domestically, it will incur a marginal cost P. But with a price of tradable permits P which is lower than P, it will only reduce its emissions to that level and will buy permits to make up the difference between Q and Q*. Area A represents the cost savings achieved through buying permits.*

The same logic applies for a source with marginal cost below the market price – on the right-hand side – with an objective Q' and a marginal cost P' that is lower than the market price P. The source will reduce emissions up to Q'* and sell the surplus permits at a profit. Its net benefit from the trade is represented by area B.*

All sources should therefore aim for a reduction strategy that results in a marginal cost equal to the permit price.

One concern about trading emission permits is that, by allowing one source to exceed its target (provided another source balances this by undershooting its target), the system could generate unacceptably high levels of local pollution. But this is not an issue for GHG, which are not the direct cause of local pollution and have the same impact on global climate regardless of the location of the source.[8] From that standpoint, GHG emissions are more suited to tradable permits than some of the pollutants that are already regulated by this approach.[9]

Emission Trading under the Kyoto Protocol: Promoting Efficiency

The starting point for an assessment of the relative cost of emission reductions by different countries is to look at their emission reduction objectives. For energy related CO_2 emissions, national circumstances – such as patterns of energy production and use, energy intensity, energy prices and also economic growth and population – are important determinants of the cost of abatement. A rough estimate of the effort required of different countries can be made by comparing their emission reduction objectives with the evolution of their emissions to date. A country which has a large reduction target and whose emissions have historically increased will have to make a great effort.

Table 1 shows the progression of energy-related CO_2 emissions for different countries, in 1990 and 1999, together with their Kyoto emission reduction targets for 2008-2012. It shows that CO_2 emissions rose

8. The trading of SO_2 and NO_x is occasionally constrained by local environmental regulations to prevent hot spots. Certain sources are therefore required to comply with their fixed local emission constraint, which may prevent them from emitting more and acquiring permits to offset their surplus emissions. On this issue and other questions regarding the applicability of trading to greenhouse gas emission, see OECD (1997): International Greenhouse Gas Emission Trading. Annex I Expert Group on the UNFCCC, Working Paper No.9. OECD/GD(97)76. http://www.oecd.org/env/docs/cc/gd9776.pdf

9. This and other questions related to emission trading as an instrument for climate change policy were addressed at an expert workshop held by the OECD in 1991 (OECD, 1992). While observers recognised some of the practical hurdles standing in the way of applying this tool to GHG mitigation, the principles of cost-effectiveness and the notion of joint implementation – a precursor of international emission trading – were introduced in the Framework Convention on Climate Change.

significantly for most OECD countries between 1990 and 1999. However the collapse of economic activity in the 1990s led to a dramatic decline in emissions in the former planned economies, to such an extent that their emissions are now below their Kyoto objective. The difference between the EITs' targets and their projected emissions is known as "hot air" in the emission trading debate. Because of these and other countries' reductions, Annex B emissions remain 1.5% below 1990 levels.

TABLE 1

CO_2 Emissions from Fuel Combustion

(Mt CO_2)

	1990	1999	99/90	Target (1)
ANNEX I	**13,811.3**	**13,591.6**	**-1.6%**	**x**
Annex II	**9,942.1**	**10,952.5**	**10.2%**	**x**
North America	5,267.2	6,074.0	15.3%	x
Canada	421.3	489.2	16.1%	-6%
United States	4,845.9	5,584.8	15.2%	-7%
Europe	3,343.6	3,368.0	0.7%	x
Austria	57.0	60.5	6.1%	-13%
Belgium	106.2	118.7	11.8%	-7.5%
Denmark	49.7	53.3	7.2%	-21%
Finland	53.4	57.8	8.4%	0%
France (2)	364.0	361.4	-0.7%	0%
Germany	966.5	821.7	-15.0%	-21%
Greece	69.0	81.5	18.2%	+25%
Iceland	2.0	2.1	3.3%	+10%
Ireland	32.2	39.9	24.1%	+13%
Italy	396.6	420.5	6.0%	-6.5%
Luxembourg	10.5	7.5	-28.3%	-28%
Netherlands	156.5	166.6	6.4%	-6%
Norway	28.5	37.1	30.4%	+1%
Portugal	39.9	61.1	53.1%	+27%
Spain	211.5	272.0	28.6%	+15%
Sweden	48.5	48.2	-0.6%	+4%
Switzerland (2)	41.1	39.8	-3.1%	-8%
Turkey	138.3	182.8	32.2%	none
United Kingdom	572.3	535.3	-6.5%	-12.5%

	1990	1999	99/90	Target (1)
Pacific	1,331.3	1,510.6	13.5%	x
Australia	259.8	321.6	23.8%	+8%
Japan	1,048.5	1,158.5	10.5%	-6%
New Zealand	23.0	30.6	33.1%	0%
Economies in Transition	3,869.2e	2,639.1	**-31.8%**	**x**
Belarus	..	57.1	..	none
Bulgaria	76.1	43.8	-42.5%	-8%
Croatia	..	19.0	..	-5%
Czech Republic	150.4	110.6	-26.5%	-8%
Estonia	..	14.7	..	-8%
Hungary	67.6	57.8	-14.4%	-6%
Latvia	..	6.8	..	-8%
Lithuania	..	13.0	..	-8%
Poland	348.5	310.0	-11.0%	-6%
Romania	171.5	86.6	-49.5%	-8%
Russia	..	1,486.3	..	0%
Slovak Republic	55.3	39.4	-28.9%	-8%
Slovenia	12.8	15.0	17.0%	-8%
Ukraine	..	379.0	..	0%
NON-ANNEX I	**6,840.4**	**8,822.5**	**29.0%**	**none**
Africa	599.7	730.3	21.8%	none
Middle East	583.7	885.8	51.8%	none
Non-OECD Europe	118.8	67.5	-43.2%	none
Other Former USSR	575.6	324.2	-43.7%	none
Latin America	919.2	1,222.3	33.0%	none
Asia (excl. China)	1,614.4	2,541.2	57.4%	none
China	2,428.9	3,051.1	25.6%	none
Marine Bunkers	348.2	423.5	21.6%	x
Aviation Bunkers	279.5	334.7	19.8%	x
WORLD TOTAL	**21,279.4**	**23,172.2**	**8.9%**	**x**
ANNEX B	**13,556.7e**	**13,351.7**	**-1.5%**	**x**

Notes: (1) The targets apply to a basket of six greenhouse gases and take "sinks" into account. The overall European Union Kyoto target is -8%, but EU member states have agreed on a burden-sharing arrangement, as listed. Because of different base years for different countries and gases, a precise "Kyoto target" cannot be calculated for total Annex I or total Annex B.

(2) Emissions from Liechtenstein are included with Switzerland, and emissions from Monaco are included with France.

e: estimated.

Source: IEA (2001): CO_2 Emissions from Fuel Combustion – 2001 Edition: 1971-1999. International Energy Agency, Paris.

The very different circumstances of OECD countries and the EITs make it likely that the EITs would be big sellers on an international emission trading market, and that OECD countries would be big buyers. The EITs have a large quantity of AAUs to sell – at no additional cost to them, some would argue –, while OECD countries have demanding objectives to meet. Transferring the EIT surplus to countries that need it will benefit both sides. Buyers will avoid more expensive measures at home, and sellers will gain important revenues.

International emission trading could also encourage *further* reductions in the EITs, and in other countries, by creating a reward for emission reductions. As a price for traded AAUs emerges, countries where the reduction cost is lower than the price should take measures to reduce emissions, accumulate additional AAUs for sale and benefit from such transactions. Buyers would benefit by paying less than their own cost of reducing emissions.

The US SO_2 Trading Programme and the Challenges Faced by International Emission Trading

The United States sulphur dioxide allowances trading programme, introduced in the 1990 Amendment to the Clean Air Act, has been a primary source of information on emission trading for the UNFCCC debate. The programme was introduced as a means to reduce the cost of curbing SO_2 emissions. It required the power sector to reduce SO_2 emissions by 50% over 15 years, by means of a cap-and-trade regime. It was a big success. Early estimates of the marginal cost of SO_2 reductions varied from $300 to $600 per tonne of SO_2.[10] Five years on,

10. $ refers to dollars of the United States.

the price was close to $150, and dropped to $70 in 1996.[11] The US experience shows that the cost of reducing SO_2 emissions through trading was much lower than it might have been for companies facing a high marginal cost of abatement.

Analysts have stressed that most of the reduction in cost – as reflected in the price of allowances – was due to the unexpectedly low cost of transporting low-sulphur coal extracted from the Powder River Basin in Wyoming to consuming states in the east. Minor adjustments to the combustion method also allowed emission reductions to be achieved more cheaply than installing end-of-pipe scrubbers. That said, the programme did foster improvements in scrubbing technology. It helped some utilities comply with their emission limits at lower cost than would otherwise have been possible (if they had sought to curb emissions themselves). It benefited others who were able to sell allowances that they did not need.

A public price soon emerged out of individual trades ("over the counter" or via brokers). The emergence of a public price was helped by the annual auction of a small share of the allowances by the US Environmental Protection Agency (EPA) at the Chicago Board of Trade.

The programme's success in creating a market incentive for efficient SO_2 abatement strategies rests on two essential features:

- All the coal power units covered by the regime had to install a continuous emission monitoring system (CEMS).[12] This system sends continuous information on emissions for each unit to the EPA. At the end of each year, each utility must surrender enough

11. For a full discussion of marginal cost, allowance prices and total cost estimates, see Smith et al. (1998). They state in particular that: "The market-based approach [of the SO_2 reduction objectives] was not the primary cause of reductions in control costs, but the approach did enhance the competition among all control methods to achieve cost reductions after exogenous events caused one control option [Powder River Basin coal] to become cheaper and more feasible." (p.12).

12. Oil and gas units can use a less costly alternative.

allowances to cover all its observed annual emissions, as recorded and reported by the CEMS;[13]

- All sources in the programme operate under one authority. Failure to cover emissions with allowances incurs a penalty of more than $2,000 per tonne of SO_2 emitted over the limit. Criminal charges can be brought against a utility employee responsible for non-compliance.

Neither of these features is envisioned in the GHG trading regime of the Kyoto Protocol. GHG emissions by countries – rather than by plants or companies – cannot be assessed in real time. Inventories take a year or more to complete, and Kyoto requires countries to report estimates rather than actual measurements. For energy-related CO_2 emissions alone – arguably the best-monitored activities covered by the Protocol – two valid procedures for estimating countries' emissions have led to very different results for some countries.[14] It is fair to say that governments, unlike companies or plants, have little if any immediate knowledge of their overall emissions, and therefore little ability to make short-run adjustments.

This has important implications for trading. Countries may not be able to adjust quickly their emissions or acquire permits to cover excess emissions, and they may find it hard to react to changes in the price of permits. Sanctions for non-compliance are unlikely to be very severe. The recent Bonn agreement made it clear that governments will not face financial penalties.[15] Governments may introduce penalties on companies for their failure to meet domestic emission targets, but are not required to do so by the Protocol.

13. EPA does not intrude in trading nor does it record the price of transactions.

14. IEA (2000): CO_2 Emissions from Fuel Combustion, IEA, Paris.

15. There is no example of a multilateral environmental agreement that includes financial sanctions when a party is in non-compliance (Werksman, 1998).

The challenge for emission trading under the Protocol is to extrapolate from a system of micro-economic co-ordination to a more ambitious form of international co-operation. Economic efficiency in GHG abatement will only be achieved if countries, or rather most sources covered by the Protocol, face the same incentive to reduce their emissions. In theory, international emission trading allows just that but the domestic policy implications are far from straightforward.

How these challenges are being addressed is the subject of chapter 4. We first turn to the estimates of the cost benefits that trading could bring under the original Kyoto agreement.



MODELLING EMISSION TRADING: HOW MUCH MONEY CAN IT SAVE?

Considerable research has been carried out on the global economic gains that are possible with international emission trading. A careful review of this work can help to assess the potential benefits of trading.

A Review of the Models: Quantifying the Advantages of Emission Trading

Models have generated scenarios that allow comparison between a situation in which each country or region meets its emission reduction obligation domestically and the international emission trading regime envisioned by the Kyoto Protocol. The results confirm what economic theory already suggests – that trading benefits both buyers and sellers. They also confirm what could be expected given the different circumstances of OECD countries and EITs – that both sets of countries stand to gain from trading. Reductions come as a windfall "profit" for the sellers. Buyers would have to pay more if they were to reduce emissions domestically. Further, both sides are encouraged by the market price to reduce their emissions below business-as-usual.

One study[16] has summarised the modelling results and looked in particular at the cost differences for different regions of the OECD. Three regimes are assessed:

- independent implementation in which each region must reach its emission target through domestic action alone;

16. This work was carried out by Dominique Van den Mensbrugghe (1998.b) while at the OECD.

- implementation through Annex B trading: countries with emission goals under the Kyoto Protocol can trade with each other;
- implementation through global trading: Annex B countries can also trade with developing countries via the CDM (the models assume that developing countries can trade all reductions arising from emissions below their business-as-usual trends).

The results for OECD countries are summarised in Table 2.

TABLE 2

Marginal Cost of CO_2 Abatement with and without Trading

($ of the year 2000 /tCO_2)

Model	No trading US	No trading Europe	No trading Japan	Annex B Trading	Global Trading
SGM	48			22	8
MERGE	81			34	24
G-Cubed	19	49	74	11	4
POLES	24	38 – 41	71	33	10
GTEM	111	228	222	36	
WorldScan	11	23	26	6	
GREEN	44	58	23	20	7
AIM	49	63	75	19	13
Average	48	77	82	24	8

Note: Differences between models can be explained by: (a) variations in business-as-usual projections of CO_2 emissions, which determine the magnitude of the effort; (b) different assumptions on the availability and cost of less carbon-intensive technology; (c) the extent to which end-use energy and corresponding prices and taxes are treated in detail, as they affect the level of the additional tax to reduce emissions.

Sources: SGM: Sands et al (1998), MERGE: Manne and Richels (1998), G-Cubed: McKibbin et al. (1998), POLES: Capros (1998), GTEM: Tulpulé et al. (1998), WorldScan: Bollen et al. (1998), GREEN: Van den Mensbrugghe (1998.a), AIM: Kainuma et al. (1998).

The key conclusion is that the more countries are allowed to trade, the lower the overall cost of achieving their targets. In particular, participation by developing countries through the CDM substantially reduces the marginal cost of meeting the targets. Relatively low energy prices and labour costs combined with fast economic growth in these countries explain the potential. The scope for improvements in energy efficiency is also broader than in industrialised countries, where significant efficiency gains have already been made.

Trading primarily enables the OECD regions to acquire emission reductions from the EITs (Annex B trading) and from developing countries (global trading). The reduction in marginal cost compared to a no-trading scenario is large: it ranges from 50 to 70% with Annex B trading, and from 80 to 90% with global trading. The marginal cost of reductions without trading is lower for the US than for Europe, and higher for Japan (although there are significant differences in model results).

Most countries would experience a small reduction in national income (the exception being those countries whose emissions are projected to be lower than their Kyoto targets). The cost of meeting the Kyoto targets through domestic action would be at most 1.5% of projected GDP for 2010 – roughly equivalent to a 0.15% drop in average GDP growth over the 2000-2010 period. Trading between Annex B countries would mitigate the GDP loss by 30 to 80% (Table 3).



TABLE 3

Kyoto Commitments: Effects on GDP

(% reductions in national income)

	No trading	Annex I Trading	Global Trading
SGM			
US	0.4	0.28	0.12
MERGE			
US	1		0.25
G-Cubed			
US	0.3	0.2	
Japan	0.8	0.2	0.2 (1)
other OECD	1.4	0.5	
GTEM			
Annex I	1.2	0.3	–
GREEN			
Annex I	0.5	0.1	-
AIM			
US	0.45	0.3	0.2
Japan	0.25	0.15	0
European Union	0.3	0.17	0.07

Notes: Model results taken from papers referred to in Table 2 notes.
(1) Result for all OECD.

Under Annex I trading, least cost reductions for OECD countries would first come from EITs such as the Russian Federation and Ukraine, resulting from the difference between their Kyoto target and their projected BAU emissions. In none of the models is this enough to cover OECD needs, and further reductions would be needed both in EITs and OECD countries themselves. In theory, all countries would reduce emissions to the point where their marginal cost of abatement equalled the price of traded emission permits.[17] Table 4 shows the expected share of targets that would be acquired through trading in different

17. See Box 2.

OECD regions. Trading would fill much of the gap between BAU emission projections and the Kyoto targets for OECD countries. Europe and Japan would acquire a larger share of their commitment through trading than North America, in the models reviewed here.

TABLE 4

Contribution of Trading to the Kyoto Emission Objectives

	% of total reductions (1)	Quantities (2) ($MtCO_2$)
Europe	63%	781
Japan (or OECD Pacific)	66%	304
North America	39%	810

Notes: These results refer to trading between Annex I countries and do not assume global trading. (1) These data were derived from the results of models sampled in Table 1. We computed the average share of commitments met through trading for each region based on these models. (2) Quantities computed using the IEA World Energy Outlook (IEA, 1998), which provided business-as-usual emission scenarios, as not all model-based scenarios provided detail on the emission growth of the different regions.

Sources: Table 2, Van den Mensbrugghe (1998.b) and Ellerman et al. (1998).



Box 3

The Clean Development Mechanism and Joint Implementation in Global Models[18]

The models under review do not use a definition of CDM that bears much resemblance to the CDM under discussion. They assume that developing countries would be able to transfer any reduction in emissions below their BAU projection*, and that an important part of the reduction would come from an increase in fossil fuel prices, to bring them into line with fossil fuel production costs (i.e., energy subsidies would be removed). In the real world, this is highly unlikely. Only part of the difference between developing countries' emission trend and reductions below this are likely to be tradable. Emission reductions would have to be verified on a project by project basis, and sector wide policies such as energy subsidy removal may not be eligible. Transaction costs, lack of information on the benefits of CDM in developing countries and uncertainty over the rules that would govern CDM also suggest that the real world will not be as responsive to market signals as the models assume. The models also project a magnitude of reductions via CDM in developing countries of around 20 to 30% relative to BAU trends for* all new stationary fossil fuel installations *between 1998 and 2010 – clearly such reductions are not likely.*

JI is also difficult to model because Annex B countries trade the same "commodity" under JI and emission trading: at the end of the day, they transfer part of their emission commitment. In most cases, reductions from JI projects are included in the trading figures of global models, as they tend to reflect a different approach to financing emission reduction activities – JI assumes foreign financing. Otherwise JI is similar to emission trading in terms of transferring reductions from one country to another.

18. Baron, Bosi, Ellis, Lanza (1999) – Emission trading and the Clean Development Mechanism: resource transfers, project costs and investment incentives. IEA Paper to the Fifth Conference of the Parties to the UNFCCC.

The IEA Model: Confirming the Advantages of Emission Trading

The IEA has carried out its own analysis of the contribution that international emission trading could make to meeting the Kyoto objectives at least cost. The models reviewed above took an aggregate view of the linkages between energy and the economy, which ignores some of the rigidity in energy infrastructure and the specific features of different end-uses, from transport to power generation. The IEA model is therefore based on a detailed description of the energy picture, but with a global overview.

The IEA model used the World Energy Model (WEM) and the projections of the World Energy Outlook (WEO).[19] The WEM is based on econometric estimates of the links between detailed economic activities, energy prices and energy consumption, and modules to optimise technology choices for power generation and fossil fuel supply prospects. This provided a more accurate energy picture on which to base the emission trading scenario. The WEM considers only CO_2 emissions and applies the Kyoto emission reduction objectives (expressed in percentage terms) to these emissions.

A scenario based on trading between Annex B countries was evaluated. These countries were divided into five regions: North America, OECD Pacific (excluding South Korea), OECD Europe (excluding Turkey and including three EITs – the Czech republic, Hungary and Poland), Russia, and other EITs (including Ukraine).

The WEO projects a considerable gap between the Kyoto commitments and projected CO_2 emissions by 2010 for the three OECD regions. By contrast, 2010 emissions in Russia and EITs will be much lower than their Kyoto commitments. Total CO_2 emissions evolve differently in

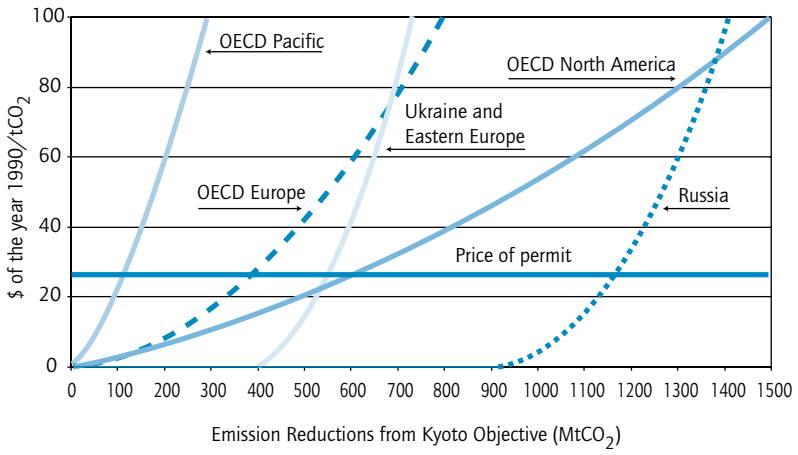
19. IEA (2000): World Energy Outlook – 2000 Edition. International Energy Agency, Paris, France.

each of the three OECD regions – increases will be greatest in North America, where emissions are expected to exceed the aggregate Kyoto commitment by 38%; less in OECD Pacific (24%); and less still in OECD Europe (17%). In the two non OECD regions of Russia and the other EITs, expected emissions in 2010 lie *below* their Kyoto commitments by 39% and 35% respectively, thus creating a reservoir of "hot air." The combined emissions of Annex B countries are projected to lie 11% above the combined commitment.

The scenario was developed using the WEO projections, and marginal abatement cost curves for each region which were derived from the WEM (Figure 3). The cost curves were calculated by imposing rising carbon tax rates on the WEM reference emission projections. (These assume no new policies beyond those adopted to date.)

FIGURE 3

Marginal Abatement Cost Curves for the Five Trading Regions



Source: IEA (2000): *World Energy Outlook.* International Energy Agency, Paris.

As rates rise, CO_2 emissions decline to below the level of the WEO reference projections. Each carbon tax rate corresponds to a reduction relative to emissions without taxes. The marginal abatement cost curves were derived by plotting this difference (abated emissions) against the tax rates which were taken to reflect the marginal cost of abatement.

The trading price was derived from the marginal cost curves, and the overall gap between the combined targets and projected emissions: it equals the marginal cost at which all five regions meet their *collective* emission reduction objective – the 11% gap between emissions and commitments of Annex B countries. The curves then indicate traded quantities region by region (Table 5). It was assumed that taxes would be introduced progressively between now and 2008-2012, as this was to be the cheapest option available to countries in the model.

The trading price based on progressive action was $26 per tonne of CO_2.[20] The relative marginal cost of emission reductions in different countries would determine the location of reductions. As already noted, countries with lower emission reduction costs are likely to be sellers, and those with higher costs, buyers. Sellers have an incentive to reduce emissions so as to maximise profits from selling the reductions. Buyers have an incentive to buy reductions from elsewhere, rather than reduce emissions themselves. On this basis, CO_2 emissions in the three OECD regions would rise by 17% in North America, 12% in OECD Pacific, and decline by 1% in Europe.[21] By contrast, EIT emissions would fall to 50% of their 1990 level, as reductions are made beyond the Kyoto objectives to meet demand from the OECD regions.

20. $32 in today's dollars. In dollars per tonne of carbon, this would be $118.

21. This scenario does not include the possibility of a second or subsequent commitment period immediately following the first one. Projections may be changed if countries must meet more stringent reductions from 2013 onward, as they would incorporate the cost of such targets in their first period trading decisions.

TABLE 5

Costs and Benefits of CO_2 Emission Trading

($MtCO_2$, $M of the year 1990, for the year 2010)

	2010 reduction target	Traded quantities (imports +, exports -)	Domestic abate-ment	Annual cost of meeting commitment with trading	Annual trading cost as % of GDP	Annual trading benefit as % of GDP(1)
North America	1,882	1,274 (68% of target)	608	39,842	0.36	0.61
Europe	631	240 (38% of target)	391	9,831	0.1	0.04
Pacific	318	204 (64% of target)	114	6,593	0.14	0.17
Russia	-908	-1,166 (hot air 78%)	258	-27,925	-5.87	5.87
Other EITs	-401	-552 (hot air 73%)	151	-12,761	-4.62	4.62
Total:	2,831	1,718	1,113	56,266	0.22	0.31
Gross (net) (2)	(1 522)	(61% of total)	(1,522)	(15,579)	(0.06)	(0.49)

Notes: (1) The average annual benefit from trading indicates the difference between the cost of fulfilling the Kyoto commitments without trading and the cost with trading during the commitment period. Given that AAUs would be internationally traded commodities, the underlying GDP figures have been calculated on the basis of US dollars converted at real exchange rates.

(2) The "gross" numbers indicate the sums for the three OECD regions. The "net" numbers indicate the sums for all Annex B regions.

Source: IEA (2000): World Energy Outlook.

These results differ from those of other models, especially in terms of the contribution made by trading to meeting regional objectives. The IEA model projects that North America would be more reliant on trading: 68% of its emission gap would be covered by trading, against the 39% suggested by the other studies. The reason is that the WEO projections assume more "hot air", arising from lower than expected GDP growth for Russia and the EITs. This allows larger purchases of AAUs by the region that needs it most in absolute terms.

The IEA analysis also suggests that the price elasticity of the North American economy is lower than other models assumed: a higher carbon value is necessary to deliver the same reduction. The marginal cost curve for North America (Figure 3) is therefore steeper than in other models: imported emission reductions compete more effectively with domestic reductions. The European results are not strictly comparable as OECD Europe includes three EITs. These countries' emissions are lower than their targets in the reference scenario and Europe's reference emissions are therefore closer to its combined target.

Trading emission reductions between developed countries would considerably reduce the cost of compliance with the Kyoto objectives, by 63% for North America, 55% for the Pacific region, and 29% for Europe. Annex B countries as a whole would save up to 89% relative to a no-trading scenario. The cost of meeting the targets for OECD as a whole if these countries traded would amount to just 0.22% of projected GDP in 2010.

These figures are based on energy-related CO_2 emissions. The inclusion of other greenhouse gases in the analysis would further lower the estimates of the overall cost of GHG mitigation. Because emissions of these gases are growing less rapidly than CO_2 from energy, the required cuts in GHG emissions would be lower than what CO_2 emissions alone would indicate . A recent study by the OECD finds that GDP cost for Annex I countries in a trading scenario is further reduced by 30% when CH_4 and N_2O are incorporated in the basket of gases from which reductions can be obtained.[22]

A Sobering Critique

The model results support the theory that international emission trading is efficient. They show that emission reduction targets are much more likely to be achieved with trading, simply because marginal costs

22. OECD (2000): A Multi-gas Assessment of the Kyoto Protocol. Economics Department, Working Papers, No. 270. ECO/WK(2000)43.

differ widely from one country to the next, which provides a tremendous incentive to trade on the differences – and cuts total cost. The models show that the savings could be very large, compared with domestic action to reduce emissions.

However the real world in which international emission trading would take place is different from the conceptual world of models and economic theory. Models assume that all sources would take part in trading, or that they would be covered with a "blanket" emissions policy such as a uniform GHG tax or a fully comprehensive domestic emission trading regime. But this is highly unlikely. It is particularly hard to imagine how all emission sources could become part of an international regime. The European Commission evaluates at 45% the share of large-scale energy-intensive sources that could be included in an EU-wide regime.[23] Other sources and sinks (too small to be monitored cost effectively), would need to be covered by specific policies and may only be linked indirectly to an international trading regime.

Models also assume that countries will be able to co-ordinate their domestic actions so that the marginal cost of GHG reduction is the same for everyone. This requires a perfect foresight of future emissions, which is difficult from one year to the next, let alone over a decade. The model results also imply huge capital transfers. Some $50 billion would be transferred annually from OECD countries to EITs as payment for AAUs.[24] It raises the issue of whether transfers on such a scale would be possible with existing financial, commercial and legal systems.

A more practical perspective on emission trading is offered in the next chapter, which considers the results of a trading simulation exercise in the power sector.

23. Green Paper on greenhouse gas emissions trading within the European Union, COM(00) 87.

24. This compares with the US$ 10.5 billion of foreign direct investment for 1995 in the Czech Republic, Hungary, Poland and Russia.



THE ENERGY DIMENSION: A POWER GENERATION CASE STUDY

The last chapter looked at international emission trading from a very broad macro economic and conceptual perspective. This is an important starting point for the development of more detailed and practical strategies to limit GHG emissions. This chapter offers a more practical perspective on emission trading in the power generation sector – the activity most likely to be covered by an emission trading regime. Some governments consider that emission trading will be the best way to curb energy sector emissions, and many companies agree – especially when faced with the less favourable alternative from their standpoint: CO_2 taxation.

Power generation is in a particularly sensitive position on CO_2 emissions. Fossil fuel combustion in power plants accounts for more than a third of industrialised countries' CO_2 emissions, more than any other activity in the energy supply chain. Power generation is a simpler target for government action than other CO_2 sources such as transport. Overall, it is well placed to develop its own emission abatement strategy because the sector ranges from carbon free wind and nuclear power to carbon intensive coal: technologies exist to reduce its emissions. Fossil fuel production companies[25] have also shown that they can deploy their own carbon emission reduction strategies, although efforts so far aim mostly at reducing their own fuel consumption and not emissions from the fuels they sell.

As we explained in the last chapter, the two most cost effective options for curbing emissions from the energy sector are emission trading or a

25. BP and Shell, for instance. They also invest in renewable energy sources, but these will not match the supply of oil for decades.

tax on emissions. However taxation raises some difficult issues: economics would suggest a single tax rate for all countries, but this has proved impractical so far. Governments that have introduced fossil fuel taxation have had to exempt power generation because it was impossible to tax electricity imports on the same basis as domestic producers (they have instead applied a general tax on electricity, which does not directly affect emissions).

CO_2 trading may have other advantages over taxation. The experience of Scandinavian countries in the mid-1990s illustrates its potential. When hydro resources were low in Norway, Denmark increased its electricity production for export. As this was largely based on coal, Denmark's CO_2 emissions grew by 22% from 1994 to 1995. Regional electricity supply was sustained at minimum cost, but emissions rose. A constraint on CO_2 and an international emission trading system would have allowed Denmark to offset the increase through the purchase of AAUs. The cost would have been covered in the sale price of electricity. Both environmental and security of supply goals would have been met in the cheapest way.

Norway's recent experience suggests another way in which trading could be beneficial. Norway, which has so far been almost entirely dependent on hydro power, has decided to install natural gas power plants to meet growing electricity demand. This will increase its emissions unless costly technology is put in place. But exporting its surplus electricity can help to reduce regional emissions if the exports substitute for more carbon intensive power production elsewhere. An international emission trading system is likely to promote this substitution as the cost of CO_2 emissions would be reflected in the price of electricity.[26] This is a finding of the emission trading simulation which we examine in the next section.

Power companies are also interested in trading because the introduction of competition in power markets puts them under pressure to reduce

26. See Baron and Hou (1998) for a discussion of electricity and CO_2 emission trading.

costs so as to remain competitive. Under the old monopoly regimes, the cost of emission constraints imposed by governments could easily be passed through to consumers. More cost conscious companies are encouraging governments to apply least cost measures to curb emissions.

It is therefore not surprising that power companies have been researching CO_2 emission trading since it was first raised in the climate change negotiations. Although there is not, as yet, an international CO_2 trading regime,[27] the first CO_2 trading system at national level was initiated in Denmark's power sector in 2001. The US SO_2 trading system is also well known to utilities around the world. The next section reviews a simulation exercise set up by a group of power companies.

Simulating Power and CO_2 Trading – Lessons from Eurelectric

Investments (not Emission Trading) Bring Compliance

Eurelectric, an association which represents power companies in Europe – including Central and Eastern Europe – organised two series of Greenhouse gas and Electricity Trading Simulations (GETS) to learn about how CO_2 trading would work in the context of an open electricity market, and the implications for power companies.[28] The simulation was a unique learning tool for the companies and provided some important insights into the strategies that they might follow if an international CO_2 trading regime were introduced.

27. For instance, international transactions have taken place between companies in Canada and the United States, but on a voluntary basis only.

28. See Eurelectric, IEA, ParisBourse (1999) for a full report of the GETS simulation.

Box 4

Rules of the Eurelectric-IEA-ParisBourse Simulation

Participants were free to choose a baseline power generation profile (fuel mix and capacity) for their virtual companies out of a common set of technologies, for a given level of power generation in 2000 (the simulation's base year). These baseline choices were made known to other participants.

The simulation covered 12 years, from 2001 to 2012, and two commitment periods, that is to say, periods within which specific emission reduction commitments had to be met. These were 2005-2007, and 2008-2012.

The companies had to supply increasing quantities of power, the level of which was only made known a year ahead. Unexpected power demand surges were introduced twice over the simulation period. The companies could satisfy demand with their own production, or buy from others, and could sell surplus production.

The companies were subject to an emissions "cap-and-trade" regime. Each company had to reduce its CO_2 emissions by 2% from 2000 levels over 2005-2007 and by 5% over 2008-2012 (these objectives were fixed arbitrarily). The emission permits amounting to these quantities were grand-fathered to participants, i.e., distributed for free.

Unused emission permits from the first period could be banked for use in the second period. Companies could start trading futures contracts in 2002 for CO_2 permits relating both to 2005-2007 and 2008-2012.

Key parameters were specified for each power generation technology, in particular construction lead times, capital costs of construction (for example 3 years lead time for the construction

of a natural gas plant). For simplicity, fuel prices were assumed to remain constant throughout the period.

Participants had to report investment decisions at the time they were made. They also had to report the breakdown of electricity generated by units of production, total electricity production, and electricity trade, as well as net CO_2 acquisitions or transfers. The IEA and ParisBourse audited these reports on a weekly basis and shared public information with all participants (investment and net traded volumes – not prices).

Grace periods were given at the end of each commitment period: participants who had exceeded their emission target and therefore needed to offset this could acquire permits from others whose emissions were below their target.

Non compliance with emission objectives incurred a double penalty: emissions above the target were deducted from the following period's target, and were also fined at 150% of the highest observed price of the previous years.

The CO_2 and electricity markets relied on anonymous transactions, through the so-called "double auction" procedure: participants offered to buy or sell a given quantity at a certain price. The best available offers (highest buying price and lowest selling price) were displayed first and no transaction could take place outside that price range. Transactions occurred only when prices were matched. If company A had offered to buy 5,000 tCO_2 at €30 – the lowest selling price at that moment – company B could acquire up to 5,000 tCO_2 at that price. The price of the last transaction was made known to all market players.[29]

29. See chapter 5 on the IEA simulation for an illustration of the double auction and its advantages over bilateral transactions.

19 European power companies from 14 countries took part in the first simulation (GETS 1) in 1999. The rules were drawn up by the Climate Change Working Group of Eurelectric, in collaboration with the IEA and ParisBourse.[30] The participating companies nominated experts to determine strategy. 16 virtual companies were set up, which traded both electricity and CO_2 over eight weeks.

Generation, investment and trading strategies under the simulation

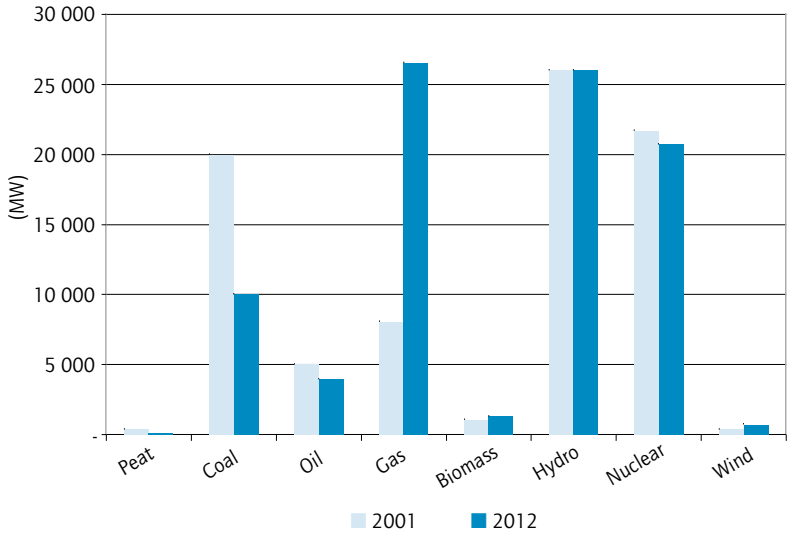
Figure 4 shows changes in installed capacity over the 12 years of the simulation. Under the assumptions adopted, a CO_2 constraint would put natural gas at a significant advantage over coal. The simulation probably exacerbated this advantage, as fuel prices were kept constant (in the real world higher demand for gas is likely to mean higher gas prices) and emission objectives did not extend beyond 2012. More stringent reductions over the longer term are likely to favour less carbon intensive generation than gas, including nuclear whose construction lead-time was probably a major barrier given the short simulation period.



30. *The IEA set up the rules under which virtual companies produced electricity and traded CO_2 and electricity, and monitored compliance of participants; ParisBourse, the company in charge of the Paris stock exchange implemented the exchange, organised internet access, monitored the numerous transactions and reported on trading sessions. Eurelectric, IEA, ParisBourse, 1999, http://www.iea.org/clim/cop5/pubs/report.pdf. A number of other simulations have been launched since but, for a number of reasons, the results have not been made public at the same level of detail.*

FIGURE 4

Installed Capacity in 2001 and 2012



Source: Eurelectric, IEA, ParisBourse (1999).

Participants' generation, investment and trading strategies were heavily influenced by their starting points. Because the companies' financial or trading performance would not be ranked, the participants chose production profiles that ranged from mainly coal-based generation capacity to a very low carbon-intensive mix consisting mostly of hydro and nuclear. Some, therefore, could rely in the near term on available, less carbon intensive capacity. Others needed to start investing immediately in less carbon intensive plant to offset a planned reduction in coal-based generation, and bought permits to cover their increased emissions until new plants came on stream. Some were net buyers in the first commitment period, and sellers in the second when their new investments materialised.

Opportunities for arbitrage between electricity and CO_2 arose where generation was reduced to avoid emissions, and power acquired from

other participants. A low CO_2 price and a high electricity price would trigger increased power sales by some participants, as it was cheaper to offset CO_2 emissions from increased generation by acquiring permits at a low price: the gains in the electricity market more than offset the cost of increased CO_2 emissions. As arbitrage opportunities were increasingly exploited, the price of traded electricity began to reflect its carbon content which was priced in line with traded CO_2 permits. This arbitrage was facilitated by trading tools that provided real time information on the best prices for electricity and CO_2. It should be noted however that electricity was traded between participants at no cost, whereas real world transactions include transmission costs.[31]

Did trading work? Were CO_2 objectives met?

Most of the virtual companies – 14 out of the 16 – met their CO_2 reduction targets. 4 companies over-complied by a significant margin. 2 companies failed to comply.[32] Their failure to meet targets arose largely from high-risk strategies that participants would not necessarily have pursued if the targets – and penalties – had been real. A closer look also reveals that these companies had failed to express their demand for permits early on, when they could have encouraged investments by other companies that could be better placed to reduce emissions at low cost. The long lead times for investment in power generation make this sector relatively inflexible, once margins to switch fuels in existing capacity have been exhausted.

Emission trading was particularly beneficial to companies with the most stringent targets. These companies relied heavily on trading to achieve their objectives.

31. In a more recent exercise, the Japanese electric power research institute CRIEPI organised a simulation in the context of the Japanese electric power industry and did introduce transmission costs in the price of traded power, based on the geographic situation of companies (Toru Ohkawara, personal communication, 24 August 2001).

32. As the simulation drew to an end, these companies started acquiring large quantities of permits, leading to a significant price increase in the grace period - more than €120 per tCO_2 from the €20-40 range observed until then. These price levels should not be interpreted as predictions of real market prices: the simulation did not replicate the power generation of Europe, neither in size nor in mix. The emission objectives were also fixed arbitrarily for the sake of this exercise.

To conclude, the simulation showed that emission trading does not guarantee CO_2 objectives will be met, but has other important benefits: a reduced cost of compliance with emission goals, and a clear price for CO_2 which facilitated abatement strategies. The factors that helped most of the companies to comply included:

- the rapid emergence of a price for CO_2 and electricity as a result of open and competitive trading;
- the option to bank CO_2 permits from one period to the next;
- the opportunity to trade CO_2 after the end of each period, during the grace periods.

Testing Alternative Rules

Participants in the first simulation noted that trading would be even more beneficial if it included other industries. A second simulation – GETS 2 – was organised for Eurelectric by PriceWaterhouseCoopers and Euronext,[33] and included participants from the oil and gas, iron and steel, cement, chemical and paper industries.[34] Other changes from GETS 1 were the option of trading electricity in futures contracts, the addition of CDM projects and the introduction of demand-side management as other options to offset emissions, and variations in fossil fuel prices.

GETS 2 differed in other important respects. Through a series of three simulations, it tested different methods for allocating reductions:

- grand-fathering: an equal percentage reduction is required from all emission sources over the same timeframe (the option used in GETS 1) and emission permits are distributed gratis;

33. Respectively one of the "big five" consulting companies, and the company in charge, among others, of the Paris Stock Exchange, formerly ParisBourse.

34. Eurelectric, Euronext, PricewaterhouseCoopers (2000).

- benchmarking: the overall target is expressed in CO_2 per unit of output and converted into caps for each participant, a way of mitigating the impact on those who start with a less carbon intensive generation portfolio;

- a mix of grand-fathering and auctioning. Half the overall target is allocated for free, and an auction is organised for the other half. The auction revenues are redistributed to participants.

The method of allocation did not seem to alter overall investment patterns, which appear to depend more on the stringency of the overall emission constraint. The allocation method did, however, drastically affect companies' financial situation. Some participants that had been net sellers under grand-fathering became net buyers under benchmarking. Auctioning had less impact, because all companies were affected in the same way – yet a free allocation of emission permits has a clear cost advantage over the purchase of these permits at an auction. Interestingly, trading was reduced somewhat under the auction method, as participants could acquire at the outset the emission quantities that best fitted their projected needs.

GETS 2 also tested a combination of 2 trading systems: one based on absolute emission caps, and another in which the constraint is expressed in terms of CO_2 per unit of output – the so called "unit sector", on the lines of the proposal developed by the UK Emission Trading Group.[35] A trading regime based on emissions per unit of output creates a risk that higher output levels will generate more emission permits and hence higher emissions. To address this issue, trading was allowed between the 2 regimes through a gateway, but included a restriction to the effect that sources from the unit sector were only allowed to sell across the gateway after checking that they

35. Under the regime foreseen in the UK, some companies are subject to absolute emission caps; others have goals expressed as GHG emissions per unit of output: how much they must acquire or can sell is a function of their overall production level. There is therefore no certainty on their overall emission level, whereas other sources are more strictly capped.

had not generated more emissions than anticipated at the outset. According to the organisers the gateway proved workable but complex.

Finally, GETS 2 introduced a third commitment period to give participants a longer time horizon for decisions, as GETS 1 had witnessed a drop in investment during the second period. Investment was nevertheless limited at the end of the simulation, implying that the decisive factor for investment may be the knowledge that there is a longer term carbon reduction objective. If the carbon constraint in 20 years' time were known, the power industry would be much better placed to optimise its investments.

Lessons from Eurelectric Simulations

The simulations proved extremely useful for companies to explore strategies to reduce GHG emissions in a competitive context. They suggested ways in which companies could exploit CO_2 as a trading asset, and how they could trade CO_2 and power together to improve economic performance and meet ambitious environmental goals at the same time. A liquid market in CO_2 can, in particular, help companies to take full account of the environmental impact of their activities in their investment choices. The construction lead times and life expectancy of power plants is generally long. The simulations showed clearly that the economic viability of new investment is quickly put to the test once a carbon constraint is applied.

The simulations did not fully reflect the real world in several important respects.[36] Trading took place between companies, who followed a single set of rules. In the real world, governments (the Parties to the UNFCCC) would remain responsible for compliance with emission objectives, whether or not these objectives are devolved to private sector entities. It is also highly unlikely that there would be a single set

36. It should be stressed that such limits are not the result of inappropriate design: these exercises have been commended by observers and been reproduced by private companies outside Europe a number of times, including the 2001 CRIEPI simulation, in Japan.

of rules: international trading is likely to develop alongside national emission trading systems. Important differences between national systems and an international regime are likely to be:

- the definition and allocation of emission objectives;
- the emission monitoring requirements;
- the commitment periods (length);
- the compliance and penalty regime;
- the monitoring role that governments could retain in granting access to the international market.

Last, the simulations could not identify the cost savings that would be made by trading. This is not so much a shortcoming of the simulations. It reflects the difficulty of computing abatement cost under uncertainty. Assessing the cost of meeting emission targets is considered in the next section.

CO_2 Trading – How Are Decisions Made?

We have showed what the possible results of applying an international emission trading regime could be. Understanding how decisions are likely to be made is also important. Cost conscious companies will want to ensure that the cost of meeting emission objectives is minimised through an effective use of trading.[37]

37. A study released in 2000 argued that a price of $5-7 per tonne of CO_2 would trigger the closure of many ageing coal power plants and substitution to gas power plants in the US. "Financial analysis of the four largest companies [American Electric Power, Southern Company, Cinergy, Tennessee Valley Authority] reveals that at a price of $5-7 per ton of CO_2, all these coal-fired units would be retired, as the carbon price would exceed their economic value" (Swift and Donnelly, 2000). The companies would shut down generation units as the expected sales of CO_2 permits would supersede power sales by these plants. This shows the magnitude of changes that a CO_2 trading system could trigger.

Elaborating Short-Term Trading Decisions

How would a power company make its decisions – whether to trade or not to trade, whether to produce and how much, whether to invest, and in what? Figure 5 is a stylised, and inevitably simplified, attempt to chart these questions through a decision tree, focusing on the near term. Starting with a simple question – are emissions above target? – companies would need to evaluate their options as buyers or sellers. The simulations highlighted that a company can start with emissions in excess of its target, and find that the price of carbon permits encourages it to reduce emissions below the target (so as to sell unused permits – middle box, left-hand side).

The decision tree includes the option of banking unused permits. A company with unused permits would need to evaluate the future cost of reducing emissions and compare this with the price that it could obtain for its permits (second box, left hand side). A relatively high price would encourage it to sell the permits, and use the revenues to invest in future reductions in emissions. Conversely a low price would encourage the company to bank permits for future use.

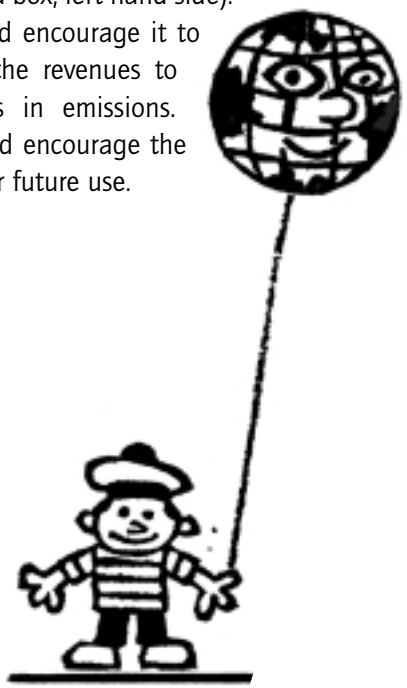
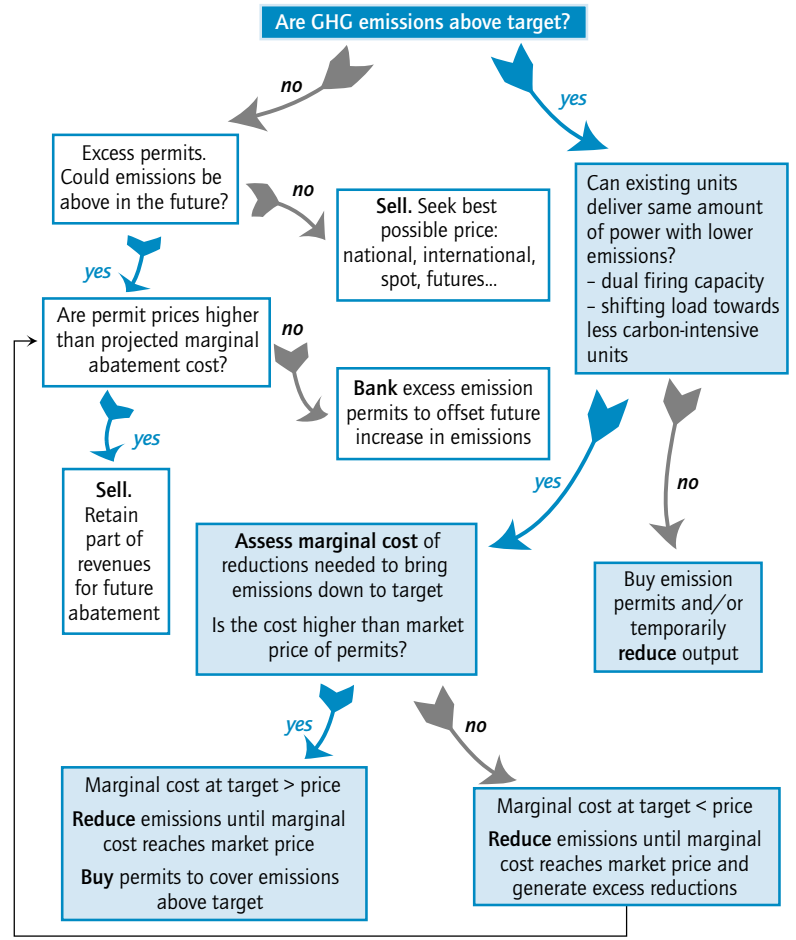


FIGURE 5

A Near-Term Decision Tree



Note: For clarity, the tree is best read starting from the "yes" branch of the first alternative; some of its elements should be, but are not, repeated in the "no" alternative. "Buy" and "sell" refer to the acquisition of any valid form of emission permit, including emission permits generated from projects to reduce emissions in other facilities / companies / countries.

The single most important issue – and also the most complex – would be the company's assessment of its marginal cost of emission abatement. A number of factors beyond the international emission trading market will influence this calculation and affect the amount of CO_2 emitted and traded at any given time. These include the future price of primary fuels, the interconnection of electricity systems, and the possible support for renewable energy (e.g., the market for renewable energy certificates):

- Electricity and primary fuel prices. A company may decide to emit large quantities of CO_2 now, if it expects to be able to offset this more cheaply in future, and may plan to do this. For example futures gas markets in the UK and US allow companies to buy gas for delivery at a future date at a price which is fixed now.[38] The futures price would help companies with gas fired power to assess the cost of abating emissions now against the cost of being able to abate them at a point in the future through increased production of gas based generation. Similarly a company with hydro power could weigh up the relative cost of reducing emissions now by tapping its reservoirs to generate more carbon free electricity, against the cost of future reductions calculated from the electricity futures market. In short, electricity and primary fuel prices determine (together with CO_2 permit prices) whether a company is better off cutting back on electricity production from certain plants, or increasing it, today compared with tomorrow.

- The interconnected nature of the electricity supply chain. A short-term abatement option for power companies that use fossil fuels is to reduce production and hence fuel consumption. However electricity systems are interconnected and power put into the grid (by generators) must equal power taken off it (by consumers), at all times. If too many generators decided to restrict production at the same time, the market would react with higher electricity prices

38. IEA (1998): Natural Gas Pricing in Competitive Markets, International Energy Agency, Paris.

– and possibly a lower carbon price due to an excess supply of permits. Higher electricity prices would of course encourage generators back into the market.

- The effect of the development of green electricity markets (produced from renewable sources, see Box 5). These markets are similar in operation to emission trading markets – governments set a target for the production of green electricity, green certificates are issued when renewable energy is produced, and can be traded to meet the target. In some countries, consumers can also pay a premium on their electricity bills to guarantee that their purchased electricity was generated from a renewable source. A power company with renewable energy capacity may decide that it is worthwhile to produce excess green power for sale, which also reduces emissions and increases profits on both markets.

Making the right short-term decisions will therefore require some advanced decision-tools. Trading electricity has already fostered the development of such expertise. CO_2 trading will add further complexity.

The power sector must also make important decisions for the longer term since most of its investments relate to long-lived physical capital. We address this longer-term perspective in the next section.

Box 5

Tradable Renewable Energy Certificates

A number of countries (at national and local government level) have introduced trading systems to support the development of renewable energy. As with emission trading, these start with an overall objective, to supply a given quantity of renewable energy (from a set of authorised renewable technologies) expressed as a percentage of total electricity production. Entities (in most cases, electricity wholesalers or retailers) are liable for meeting this objective, and a system for trading so called green certificates

(proof that a given amount of renewable electricity has been produced) is put in place to facilitate their task.

For instance, a company that must supply 100 GWh of renewable electricity may produce 80 GWh and acquire green certificates for the remaining 20 GWh, if the extra cost of generating 20 GWh with renewable sources is higher than the cost of buying certificates.

As green certificates are no more than proof that a given quantity of renewable power has been produced, they are traded independently of the electricity itself. They should also be distinguished from the marketing of green electricity, whereby consumers may choose to pay a premium for the certainty that part of the power they consume comes from renewable sources. In some countries like the Netherlands, companies produce more renewable electricity than the agreed target, in order to meet consumers' demand for renewable electricity.

The relationship between a green certificate and a CO_2 emission permit is not straightforward. A generator may exceed its renewable power target – a percentage of total output – and fail to meet its CO_2 target if its electricity output has increased significantly. It could therefore sell green certificates, but would need to buy CO_2 permits. But it could also exceed both targets. The possibility of an exchange rate between green certificates and CO_2 permits is envisaged by Schaeffer et al. who find that such an option "can be regarded as effectively introducing a variation on the GHG emission limits agreed by negotiation". [39]

Countries that have introduced or are considering the introduction of green certificates include Austria, Australia, Belgium, Denmark, Italy, the Netherlands, Sweden, the UK and the US (including initiatives by individual States).[40]

39. Schaeffer et al. (1999), p. 79.
40. Hamrin, 2001.

Long-Term Options

A much wider range of strategies to meet emission targets becomes available over a 20 to 30 year time horizon. Old capacity is retired, investment opportunities automatically arise, and technology develops. But at the same time, investment in power plants, once made, is largely irreversible for the lifetime of the plant, so options need to be carefully considered in order to avoid future stranded assets – investment that will become uneconomic under future market conditions. What factors are likely to shape – and ought to shape – power company decisions on investment?

One factor that could become important in international investment is the option of internal company trading in emissions. This may develop with mergers and acquisitions in the power sector, international as well as domestic. Based in a range of countries, companies would come under environmental regimes of varying strength, and face varying emission reduction costs. It is unlikely that countries will follow the same policy options for curbing emissions. Some will establish domestic emission trading regimes, some will allow project-based reductions to be transferred, others will favour efficiency standards, or support for renewables or combined-heat and power.[41] Under an international emission trading regime, a company's ability to trade CO_2 permits would become part of its assets (or liabilities), and would be reflected in its market value. A company with emissions below its target would have a higher value than a company with a similar generation profile but which is not subject to an emission cap. A company with a high level of emissions could, however, be an attractive investment if its marginal cost of abatement is lower than the investor's – and lower than the price of CO_2 permits.

Emission constraints would be a major factor in investment choices. But it is not – yet – clear what constraints will apply 20 to 30 years from now. Investment choices are being made today in ignorance of the CO_2

41. Some of these policies may not be immediately compatible with an international emission trading regime.

constraints that may exist over the longer term. We note that no new nuclear plants were installed in the two Eurelectric simulations: it is possible that more stringent emission targets beyond 2012 – and correspondingly high CO_2 permit prices – would have tipped the balance away from gas towards renewables and nuclear. Companies are also looking at options that may look costly today but could fundamentally change the approach to CO_2 reductions: the capture and storage of CO_2 before it is released by power plants.[42] If today's investment decisions are to be shaped by a 20-30 year vision, the message from this analysis is that clear decisions on long term CO_2 constraints and on an international trading system are needed today in order to maximise the prospects of getting investment right for the future, and to avoid major long term CO_2 emission problems.

Energy Decisions Call for a Carbon Price Now

The power sector seems well equipped to implement an emission trading system in order to manage its CO_2 reduction efforts. A number of political questions relating to allocation and competitiveness are yet to be solved, but emission trading does guarantee that any power generator which participates would offset its emissions in the cheapest possible way.

At the same time, the power sector must take long-term decisions: unless a reliable market price for CO_2 emerges quickly, it will be difficult for this sector to engage on the lower emission path that will eventually be imposed by governments to slow global warming. The establishment of more transparent electricity and gas markets is already a great help.

42. This technology cost currently $40 to 60 per avoided tonne of CO_2. According to Wallace (2000), "this compares favourably with other options such as the widespread use of renewable energy sources... The cost of CO_2 capture and storage is approximately equivalent to an increase in the price of electricity of 1.5 – 3 cents per kWh. For comparison, in 1998, domestic electricity users in the OECD paid 7 – 14 cents per kWh. Industrial users paid 4 – 9 cents."

Futures gas and electricity contracts, for instance, provide both the critical information needed to assess the longer-run implications of today's investments, and hedging mechanisms to secure their economic viability. But the power sector now needs similar CO_2 markets.

Over the last few years, the reform of electricity and gas markets has led to the view that a generalised "dash-for-gas" would take care of the CO_2 emission problem in the power sector, without the need for additional government intervention, whether emission trading or other action. But this idea needs closer scrutiny. First, the 20% decline in CO_2 emissions from the UK's power sector between 1990 and 1998 is dramatic, but probably exceptional, as few countries combine the UK's historically high share of coal in power generation and domestic access to large natural gas resources. Second, the increase in gas prices that may result from a "dash-for-gas" could undermine the economic viability of this option. Last, if CO_2 emission reductions were taking place at low cost, the power sector's participation in the trading regime would help others to minimise their cost of compliance through the purchase of permits freed-up by the shift to natural gas production.

Analysis of the power sector with a carbon constraint and emission trading is only part of the bigger picture. The discussion of emission trading has focused on large stationary sources of GHG emissions, but other industrial emission sources must be included if emissions are to be reduced at low cost. However emission trading is not straightforward for other sources. Transport emissions raise big problems, as they arise from a multitude of small sources. In theory, greenhouse gas objectives could be assigned to fossil fuel producers and importers, giving them the responsibility for CO_2 emissions embedded in their sales. The price of CO_2 permits could be reflected in fuel prices, and thus be disseminated to all energy users. But this would turn the emission trading system into a CO_2 tax, which is a politically difficult prospect for most countries at present. Another option for transport would be to assign objectives to car manufacturers, based on estimates of their cars' CO_2 emissions. The extra cost of the carbon

constraint would be passed on to car owners and would provide an incentive to acquire less CO_2 emitting cars. While not unfeasible, these options raise a number of challenges, and other measures are being considered.[43] Overall, the least-cost potential and the price signal that emission trading would provide might not be conveyed to all GHG-emitting activities.

The Eurelectric case study does offer important lessons beyond power generation: emission trading will not be technically difficult, given a clear set of rules. But the role of governments is crucial and needs further examination. And sound investment strategies will be the main factor in meeting environmental goals: emission trading simply puts a price tag on reduction efforts.



43. Some of these policies address the broad framework under which transportation choices are made, e.g. town-planning. It is not clear how trading systems applied to transport would provide direct incentives to influence such decisions. If applied to transport, trading systems would probably need to be supplemented by other measures. See IEA (2000): The Road from Kyoto – Current CO_2 and Transport Policies in the IEA. IEA, Paris. See Winkelman, Hargrave and Vanderlan (2000) for a discussion of options to apply emission trading systems to the transportation sector.



DEVELOPING RULES FOR INTERNATIONAL EMISSION TRADING

The cost savings projected by the models, and the adaptation of the power sector to meeting CO_2 objectives, assume that an effective international trading regime is in place. In early discussions it was generally assumed that a cap on emissions would be enough to ensure a viable system. Unfortunately the real world is not so simple. All trading systems need rules. In particular, the Kyoto Protocol framework requires rules for a system in which caps apply primarily to governments, not to companies.

In Bonn in July 2001, Parties to the UNFCCC agreed on the basic rules that will govern the international emission trading system (details have yet to be settled). Most importantly, countries will need to place a significant portion of their assigned amount in a reserve to limit the risk of "overselling." Another key issue was possible limits on the use of trading to comply with emission goals.

This chapter covers these and other institutional rules which are necessary for the establishment of the trading system.

Setting Up the System: Quantified Targets, Eligibility and Monitoring

The starting point for an effective international regime is the need to quantify objectives. The Kyoto Protocol takes this only part of the way. It defines objectives as percentages of the Parties' 1990 emission levels. However 1995 can be used as the base year for the three

fluorinated compounds[44] and EITs are free to choose another year on which to base their objectives. Also, not all GHG emissions (and removals by sinks) were appropriately monitored in 1990 or 1995. Emission trading in itself does not create this difficulty: it is the legally binding nature of the objectives that calls for a precise tally against which Parties' emissions in 2008-2012 will be measured.

Measuring emissions during the commitment period (and emission reductions through sinks) is equally crucial. It requires accurate monitoring of all the emission sources covered by the regime, as well as tracking of assigned amount units (AAUs, which are emission permits under the Protocol). These are two essential elements for determining compliance, and to provide reassurance that some countries are not free riding on the agreement (by underestimating emissions, or inflating the number of AAUs held). Effective measuring also implies that emission sources that cannot be easily monitored should not participate in the regime. Confidence in the system and in its environmental integrity is crucial, not least because emission trading puts a monetary value on emissions and thus provides a potential incentive to cheat the system.

Measuring and Monitoring Emissions

As well as defining objectives, the Kyoto Protocol requires countries to prepare national inventories of their GHG emissions (and removals by sinks) "using comparable methodologies."[45] It also launches a process to agree on the methodologies. Systems must be in place by 2007 at the latest. Inventories will, of course, be used by governments to help define trading strategies, for example whether they will need to acquire AAUs or implement new domestic measures.

Unlike domestic systems, an international trading regime involves a myriad of emission sources that cannot be directly measured and for

44. HFCs, SF6, and PFCs.

45. Articles 4.1.a and 12 of the Framework Convention on Climate Change.

which estimates are needed. The quality of CO_2 statistics for the energy sector alone varies from country to country. Two different methodologies are currently considered acceptable.[46] The Reference approach is based on the overall level of consumption of fossil fuels (production plus imports less exports). Adjustments are made for the non-energy use of fuels, and emissions are calculated from the emission coefficients of the different fuels (kg of CO_2 per unit of combusted fuel). The Sectoral approach relies on observations and surveys of energy consumption at a more detailed sector-by-sector level.

The two approaches do not always show similar trends. Between 1990 and 1998, the Reference approach shows an overall decline of 3.3% in Annex B Parties' emissions, against a decline of 2.3% under the Sectoral approach.[47] This is a difference of 140 million tonnes of CO_2 for 1998 alone, which is hardly negligible given that annual trade is projected to be around 1,700 million tonnes.[48] Even wider discrepancies can occur at country level. For example the growth of CO_2 emissions for France is 1.9% under the Reference approach compared with 8.4% under the Sectoral approach. There are genuine technical difficulties in explaining these differences. Even where statistics are well developed, uncertainties over actual emissions can remain.

The tools for domestic implementation of the Kyoto Protocol – and for meeting other environmental goals – can help the measurement and monitoring process. Taxes or domestic trading systems also require an effective inventory – or estimate – of emissions.[49] For example monitoring under the US SO_2 allowances programme includes monitoring of CO_2. But the contribution of certain activities will remain difficult to gauge with accuracy. Biological sources in agricultural and

46. These methodologies are defined by the Intergovernmental Panel on Climate Change in its programme on guidelines for inventories of greenhouse gases. http://www.ipcc.ch

47. IEA (2000): CO_2 Emissions from Fuel Combustion – 2000 Edition. OECD, Paris.

48. IEA (2000): World Energy Outlook 2000. OECD, Paris.

49. For example, drivers in some countries pay taxes on certain emissions that can only be estimated from the carbon content of the amount of fuel that they purchase. Actual emissions depend on the quality of combustion, which happens after taxes have been disbursed and would be much more costly to assess.

forestry activities[50] for which ready-made indicators do not exist are potentially challenging. These sources will always require a mix of sampling and approximation.

Because emission trading gives an economic value to emission reductions, countries must generate a minimum amount of confidence in the accuracy of their GHG inventories to reduce concerns about mishandling of inventories to raise additional revenues from trades – or avoid reductions that they need to make. This is why appropriate GHG monitoring and reporting mechanisms are essential eligibility criteria for international emission trading.

A Registry System for Tracking AAUs

The second essential element for ensuring compliance is the need to track the AAUs that each country must hold to cover its emissions under the terms of the Protocol. National registries are proposed to track countries' holdings of AAUs.[51] Each country's registry would start with its initial AAUs and would be adjusted up or down to reflect AAU acquisitions and sales.

What form would a national registry take? It would be an electronic record of AAUs – similar to stock or share recording certificate systems. Each AAU would be labelled to identify the country of origin (the issuing Party or seller) and carry a serial number and the date at which it was included in the registry. Transactions would not change this basic information, so that AAUs could always be tracked to the original seller.

AAU transfers would be made directly between national registries. The registries could also contain information on the partners in a transaction. For instance, country WW could sell AAUs it had acquired from country

50. The so-called land-use, land-use change and forestry activities of the Kyoto Protocol. The Bonn agreement, in its Annex Z, includes a limit on the extent to which individual Parties can use forest management activities to offset their emissions, as this is an area where precise estimates are most difficult (UNFCCC, 2001).

51. AAUs, but also Certified Emission Reductions (CERs) generated by projects under the Clean Development Mechanism and Emission Reduction Units (ERUs) for projects undertaken under Joint Implementation in other Annex I Parties. AAUs, CERs and ERUs are equally valid compliance tools.

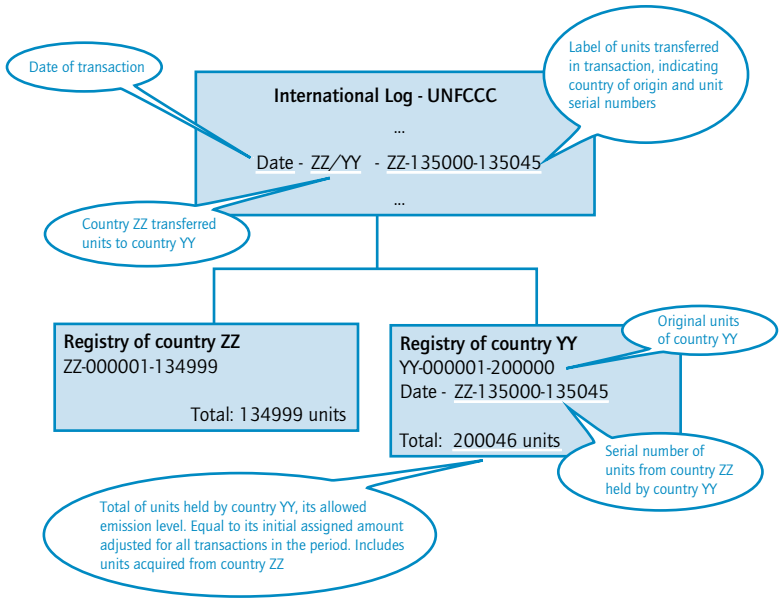
XX to country YY and this information would be recorded. This would be used to track AAUs, as they are likely to be traded several times over.

It is also proposed that the UNFCCC Secretariat keep a log of all transactions from one registry to another, to ensure that AAUs are located in one registry, and are not being used more than once.

Figure 6 and Figure 7 illustrate the proposed operation of the registry system.

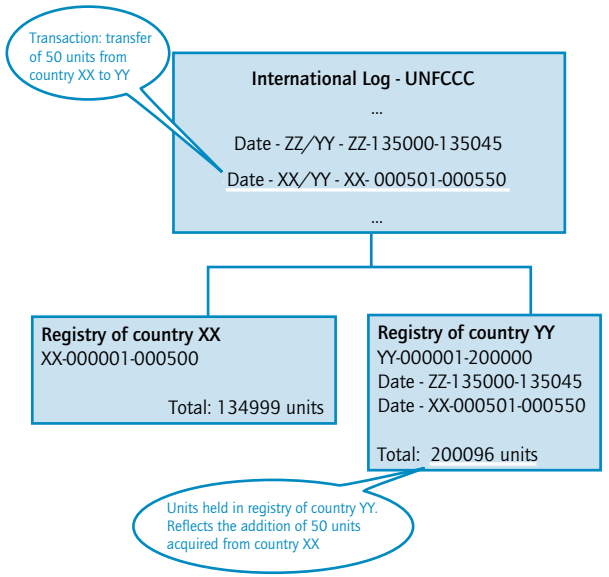
FIGURE 6

Illustration of National Registries (1)



Note: This shows the registries of countries ZZ and YY after the former transferred 46 units (AAUs) labelled ZZ-135000-135045 to country YY. The international log would record the date of the transaction as well as the two Parties and the serial numbers of the transferred units.

Figure 7: Illustration of National Registries (2)



Note: Here, country XX has transferred 50 units to country YY, which now holds its own units, labelled YY, and units acquired from countries ZZ and XX.

The registry system would be separate from the commercial trading of AAUs: it is a bookkeeping tool, not a platform for trading. Commercial transactions would be negotiated (and recorded separately) on trading exchanges or bilaterally. Registries would only record transactions once they had been agreed (derivative transactions – options, forwards and futures – would only be recorded once the actual transfer between registries had taken place). They would not hold information on prices so as to maintain confidentiality for private sector participants in the system (see later section in this chapter on private sector participation).

Registries could cover other important tasks under the Protocol. As well as covering sources of CO_2, they could also cover the removal of CO_2 by sinks. Net emissions resulting from land use, land use change and forestry activities would be taken into account by removing AAUs from

the registry (via a cancellation account) and the absorption of CO_2 by a country would increase the number of AAUs. The registry would record and label all such operations.

The registries would also record companies' use of AAUs, where a country has devolved part of its objective to sources under a domestic emission trading arrangement. A company may find itself in 2012 with more AAUs than it needs to cover its 2008-2012 emissions and could bank them for a future commitment period. This means that the banked AAUs should not be counted against that country's commitment, although they do appear on its registry. So-called retirement accounts would deal with this issue: companies would move AAUs needed to cover actual emissions into these accounts, and banked units would remain in the main accounts. AAUs held in the retirement account would be used to assess the country's compliance. As Article 3.13 of the Protocol does not allow banking by a country that is out of compliance with its emission target, a country's registry could only carry AAUs from one period to the next if it had retired enough units to demonstrate compliance.

Setting Up the System: Liability and Enforcement

Accurate monitoring of emissions and an effective registry system to record AAU transactions are both essential to establish confidence. We noted earlier that they constitute the minimum eligibility requirements set by the Kyoto Protocol for participation in an international trading regime. But confidence also hinges on effective enforcement. The harmonisation of domestic compliance regimes is very unlikely. Countries have been reluctant to discuss it so far as different cultures, economies and legal systems have given rise to very different domestic approaches.

However the need for a framework of agreed international rules to strengthen the prospects of compliance – even if domestic regimes are not fully harmonised – is widely acknowledged to be crucial. Some regimes are stricter than others, and this gives rise to concern that AAUs may be more easily acquired from countries with a relatively soft approach to enforcement. For example a low penalty for non-compliance in one country may lead to important AAU sales abroad, if the penalty is lower than the price at which AAUs can be sold. This could reward non-compliance, that is to say, a country may trade more AAUs than it is entitled to (the issue is known as overselling). Concern about overselling is a major factor behind the efforts to negotiate international rules.

The task is not an easy one. As with monitoring, the compliance issue for an international regime is considerably more challenging than for a domestic one. Under the US SO_2 allowances programme, a plant that has emitted excess SO_2 (or sold allowances in excess of its emission limit) is directly responsible for the failure to comply. It faces a financial penalty[52] and, because it is still required to meet its missed obligation, the excess is subtracted from its future allowance, which adds to the compliance cost. Because non-compliance is easy to track and the penalty is much higher than the price of allowances, no company has, so far, failed to meet its obligation.

The reality for an international system is very different – there is no prospect of an agreed financial penalty, and until the Bonn agreement, there was no rule on how to subtract excess emissions from a country's future allowance.[53] Efforts have focused instead on how liability would be allocated in cases of non-compliance caused by overselling.

Article 3 of the Kyoto Protocol offers a starting point. It puts the responsibility for holding a sufficient number of AAUs to comply with

52. Adjusted for inflation, the penalty amounts to US$ 2,682 per tonne emitted above the allowance level.

53. In Bonn, Parties agreed to a restoration rate of 30%: any compliance shortfall, i.e., emissions above a Party's assigned amount, would lead to a deduction of its assigned amount for the following budget period of an amount equal to 130% of that shortfall (UNFCCC, 2001).

emission objectives on each country. In other words, the seller is liable if there is overselling. Without further clarification, the Bonn agreement confirms that this is the liability option that will govern the trading regime. Other liability options to deal with overselling (whether deliberate or not) have been proposed, but would result in different market structures.

Assessing Different Liability Options

There are arguments for and against different liability regimes, in terms both of likely environmental impact (can they effectively reduce overselling?) and of economic efficiency (how efficient will the market be?). We consider below the most important.[54]

Buyer liability

Consider a regime based on buyer liability. If a buyer has acquired AAUs from a seller that ends up in non compliance, the purchased AAUs may be devalued or even cancelled (the two options under consideration aimed at restoring the system's environmental integrity). The main argument in favour of buyer liability is that it creates a strong incentive for the buyer to assess the seller's compliance prospects. If the seller's prospects seem uncertain, its AAUs will be devalued by the market, because they cannot be used for compliance. Countries would need to distinguish between the AAUs of different countries, as AAUs would have different values: an AAU from Ukraine may not be valued the same as an AAU from Hungary, for example. Under buyer liability a buyer would need to know the AAUs' country of origin before it agrees to a purchase, and separate markets could even develop.

54. *An early paper provided a first assessment of eight different rules for liability under international emission trading, based on either seller liability, buyer liability, the so-called "traffic light option", shared liability, and options based on various forms of AAU reserves to prevent overselling. These options were assessed against environmental effectiveness, costs, market confidence and participation of companies. See Baron (1999):* An Assessment of Liability Rules for International GHG Emissions Trading, *IEA Information Paper, International Energy Agency. For a full quantified assessment, see Haites and Missfeldt (2001): "Liability rules for international trading of greenhouse gas emissions quotas",* Climate Policy 1 *(2001) 85-108.*

From a commercial and economic standpoint the additional regime could be complicated and perhaps inefficient because of the additional transaction costs. In particular, it raises the issue of how to cancel trades that put a seller out of compliance, and how to deal with the acquisition of AAUs by companies to whom countries have devolved part of their target, if these are later invalidated.

Seller liability

A regime based on seller liability – the approach confirmed at Bonn – would be very different. The buyer would not care about the origin of AAUs, and they would be traded on price alone. In itself, the regime could prove weak against overselling. A country or company could decide to increase its wealth – or obtain financing – by selling AAUs that it needs for compliance. Emission trading introduces a financial perspective in the efforts to limit emissions, which needs to be balanced somehow in order to avoid creating a new kind of international debt – on the global environment. The potential benefits of an international emission trading system would also be undermined if massive overselling were to result in non-compliance. The system would not have delivered an effective price signal to the market – prices would be artificially low if overselling were important – and the usefulness and relevance of emission trading could suffer. Of course, rogue sellers that are identified could be blacklisted and debarred from trading by buying countries.

Seller liability does have the advantage that AAUs would retain an equal value: because the seller is liable, the buyer can use the AAUs for its own compliance needs regardless of the seller's situation, and this may foster a more efficient and less cumbersome market.

Mixing buyer and seller liability

Seller liability, without penalties, may not be strong enough to limit the risk of overselling. Buyer liability may be too cumbersome and put

undue pressure on buyers when, at the end of the day, it is the seller who should ensure that AAUs do not leave its registry if it is short of its emission target. Proposals have been tabled that draw on both options, either to share the overall liability or to make both buyers and sellers liable. The sellers would be responsible for oversold AAUs, but buyers would also lose parts of the acquired AAUs. This double liability rule would therefore more than offset the invalid transaction.

Another proposal to deal with the weakness of seller liability is to trigger buyer liability if and when a country shows signs of non-compliance – although proposals have never made it clear how to define these signs. When non-compliance became clear, the country would be forbidden to transfer any AAUs. Under this so-called traffic light option,[55] early buyers would own secure AAUs if they were purchased before any non-compliance problem is identified (green light). If the yellow light were applied after a compliance problem occurred, transferred AAUs could be subject to devaluation if the seller defaulted on its obligations; the red light would stop all trading from the seller. But the traffic light rule would add little to the buyer liability regime: in the latter, countries for which compliance is secured would sell at a relatively high price, equivalent to what they would get under a yellow light in the traffic light system.

One major difficulty for the traffic light option is the definition of what would constitute a compliance problem to trigger the yellow light, and the threshold beyond which all trades should be stopped (red light). From the market viewpoint, participants would be faced with units of a very different nature depending on the selling Party, but also on the date at which the AAUs were issued and their status (green or yellow light) at that date. Would this option be effective to prevent deliberate overselling? Probably not: AAUs sold before the problem is spotted would be under a green light and not prone to devaluation.

55. Goldberg et al. 1998.

Mandatory Reserves: a Weapon against Overselling?

None of these options directly addresses the issue: the risk of overselling. Instead, they try to avoid the problem by introducing incentives for market players to be aware of their own risk exposure.

Another option was eventually adopted by countries to minimise the risk more directly: countries should retain part of their initial assigned amount in a reserve. The level of the reserve is to be set to reflect the emission levels of the country. The logic is simple: a country should only be able to sell AAUs corresponding to quantities over and above its emission level.

Two approaches similar to the reserve idea were proposed earlier. The first called for an annual retirement of AAUs as countries submit their annual inventories for the commitment period. If a country reported 150 MtC emitted in 2008, the equivalent in AAUs would be taken out of that country's registry, as the country would need this to cover its 2008 emissions. This option would not be enough to limit overselling, as nothing would prevent a country from selling four fifths of its initial assigned amount after setting aside one fifth for its 2008 emissions.

The second option allowed countries to trade only after proving that their emissions were below their assigned amount. As this would postpone all trades until after the end of the commitment period, it has been suggested that the approach be applied on an annual basis during the commitment period.[56] Countries would first define their annual emission profile over 5 years, consistent with their overall emission objective. An annual comparison of actual emissions with the emission profile would determine how much the country could transfer. A country whose emissions were higher than its profile would not be allowed to transfer AAUs that year.

56. Switzerland, submission for the 10th sessions of the Subsidiary Bodies of the UNFCCC (1999).

One problem with the so called post-verification option is that the market could be subject to erratic variations, depending on annual emission inventories. Also, the time lag between emissions and the official inventory – up to three years at present – could postpone most trades until after the end of the commitment period. The price signal after 2012 would have no influence on the supply of AAUs for the first commitment period. This rule would thus reduce overselling, but at the expense of a less efficient trading system.

The reserve proposal adopts an intermediate approach: each country must set aside a part of its total assigned amount (five years' worth), but is free to trade the remainder, i.e. its projected surplus over five years. The critical issue is of course what should be set aside. In a perfect world, sellers would know their 2008-2012 emission levels and would therefore be able to calculate the tradable amount (their assigned amount minus emissions over five years). Such foresight is impossible, so proxies for 2008-2012 emissions must be used. These include projections based on five reviewed greenhouse gas inventories or, more simply, the latest available reviewed inventory. For instance, a country that has completed its inventory for 2004 which shows that it is 15% below target could transfer 15% times its assigned amount for 2008-2012. As new inventories became available, the reserve level would be adjusted accordingly. A country whose registry is at the reserve level would be prohibited from selling until its emission inventories demonstrate that emissions are lower, or it has acquired enough AAUs[57] from other countries to be above its reserve level.

Like other options, the reserve has drawbacks. First, early inventories may not accurately reflect future emission levels: this could result in some overselling – but possibly also underselling – during the commitment period. Some valid transactions could be postponed until after 2012, possibly resulting in loss of efficiency. Another problem with the reserve approach is that, applied blindly, it would prohibit any

57. Or CERs from the CDM and ERUs from JI projects.

country with emissions above its objective from selling AAUs during the commitment period. At first glance, there seems to be no reason why these countries should be allowed to do so. However, they may have allocated AAUs to domestic companies which, if they were over-achieving their emission objectives, should be allowed to sell them at the best possible price, possibly on the international market. Of course, there is a risk of overselling from these countries as well, if the governments fail to properly manage their overall objective. But allowing these countries (and their companies) to trade some part of their assigned amount would add liquidity to the market, make it more competitive and thus more efficient.

In order to counter some of these effects, the reserve agreed in Bonn distinguishes implicitly between net buying and net selling countries. One alternative allows for a choice of two levels for the reserve.[58]

- the latest reviewed inventory multiplied by five – countries with emissions lower than their assigned amount would be able to trade their surplus under that option. Earlier proposals had suggested between 60 and 100% of the latest inventory. The higher level should be more effective in reducing overselling – but may postpone some valid transactions until after inventories have been collected for 2008-2012. Countries and companies could enter forward or futures contracts to secure later transfers, once the reserve allows them, and bring such information to the market. Such transactions would carry an additional cost and may affect the efficiency of the market;
- 90% of the initial assigned amount. Countries that need to buy could still transfer 10% of their initial AAUs. These countries would need to be net buyers in the end, but would not be prohibited from transferring AAUs on occasion. Earlier proposals had ranged between 60 and 98%.

58. UNFCCC, 2001.

With this second option, the reserve is unlikely to constrain market liquidity in any serious way: 10% of buyers' assigned amounts can be traded freely until countries need to retire them for compliance, after 2012. Governments will nevertheless need to work to turn this constraint into an operational mechanism at domestic level. Whether the reserve affects the overall efficiency of trading is and will remain uncertain until actual trading starts.

The reserve is a good illustration of the bigger question of how to design an efficient trading system for environmental policy. The perception that the cost of emission reductions could be very high has been the main driver behind the idea of emission trading at international level. Hampering its efficiency with too many burdens on transactions would be a problem. But the risk that the regime could create perverse incentives that led to overselling and the corruption of environmental goals has been an equally significant concern.

Other issues

"Supplementarity" and "Hot Air"

"Supplementarity", that is to say the need to rely on emission trading as a complement to reductions undertaken at home, has been one of the most significant barriers to a full endorsement of international emission trading by industrialised countries. It has also been raised by some developing countries who worry about the principles that may apply to their future participation. Essentially, the question is one of location: where may countries reduce emissions, at home, or abroad? Those (such as the EU) advocating limits are concerned that countries may not undertake policies to curb domestic emissions if they can offset these by acquisitions of AAUs. The perceived risk is that rising emissions in buying countries will make it impossible to negotiate the more ambitious reduction objectives needed to stabilise greenhouse gas concentrations. This group advocates that "emission trading should

be supplemental to domestic actions" and has tried to find ways of turning this principle into practice. They are not opposed to emission trading: it is more a matter of degree.

An alternative view (taken by the Umbrella Group[59]) is that the market will define the balance between domestic action and AAU acquisitions. More stringent future objectives would be reflected in today's prices of traded AAUs. Markets and technologies would evolve accordingly. It is also argued that if objectives were agreed together with the inclusion of the flexibility mechanisms, the expected use of these mechanisms would dictate the acceptable target level. In other words without emission trading, objectives may not be met, or even adopted.

Indeed, flexibility mechanisms cannot be discussed in a vacuum. Most OECD countries have agreed to objectives that imply a significant reduction from their current emission trends, while EITs were given some flexibility, reflecting the economic recession that led to a sharp decline in their emissions. These countries' emissions are expected to remain well below their target, they will have a large amount of AAUs for sale, and will not have taken measures to reduce emissions at home. This so-called "hot air" for sale is an opportunity for buying countries to delay mitigation measures at home – even if the Kyoto targets imply real reductions among Annex I Parties as a whole. On the other hand, even with "hot air", the international market price creates an incentive to pursue domestic mitigation options with lower cost. Solving this debate may only be possible after a full test of emission trading. In a nutshell, the EU has been trying to guard against problems before they occur, while the Umbrella Group has adopted a "learning by doing" approach.

Turning the supplementarity principle into action is not straightforward. It suggests that most reductions should be made at home. This requires an estimate of the necessary reductions, i.e. the difference between a country's projected emissions for 2008-2012 and

59. Before the United States withdrew from the Kyoto Protocol, the Umbrella Group consisted of Australia, Canada, Japan, New-Zealand, Norway, the Russian Federation, Ukraine and the United States.

its assigned amount, with an obvious problem: are projections accurate? The EU has tried to solve this with a proposal for ceilings on the flexibility mechanisms, basing the ceilings on verifiable quantities such as the country's assigned amount and its observed emissions.

Box 6

EU Proposal for a Concrete Ceiling on the Use of the Kyoto Mechanisms[60]

The EU proposal is divided in two sections – rules for "buyers" and rules for "sellers." Buyers have two options. Annex B Parties' purchases may not exceed the higher of the two quantities below:

(1) 5% of [(base year emissions multiplied by 5) + (assigned amount)] / 2

(2) 50% of the difference between the actual annual emissions of any year between 1994 and 2002 multiplied by 5, and its assigned amount.

The EU proposal does include a provision that would allow an Annex B Party to purchase more emissions than the amount defined by the ceiling. This would only be possible if it achieved emission reductions, through verifiable domestic policies and measures undertaken after 1993, greater than the amount allowed under the ceiling. The additional amount that could be purchased would be limited to the difference between the reduction achieved domestically minus the total amount that could be purchased under the formulae. For example, a country that has a ceiling (under rule 1 or 2) of 25 tCO_2 and implements domestic measures resulting in a reduction of 40 tonnes would be allowed to increase its purchasing ceiling by 15 tCO_2 (40-25).

60. European Union Council (1999): Council conclusions on a Community strategy on climate change, 17 May 1999. See also Baron, Bosi, Lanza and Pershing (1999): A preliminary analysis of the EU proposals on the Kyoto mechanisms, IEA Information Paper, 28 May 1999.

Rule 1 would also define how much sellers would be able to transfer to other countries. Sellers that can show they have achieved more reductions domestically than sales would, however, be allowed to transfer the difference. A review process would determine if the country has really achieved these reductions before it is allowed to engage in further international transactions.

The rules would have very different effects on countries. For instance, countries with exceptionally high emissions in one year between 1994 and 2002 would be granted considerable flexibility under rule 2, if they expect to achieve significant domestic reductions over 2008-2012. For others a restriction on acquisitions would apply. At the time this proposal was made, the IEA found that the rule would allow buyers to acquire a total of 1,091 $MtCO_2$ or roughly a third of the total gap between expected 2010 emission levels under BAU and the Kyoto Protocol target. But the most significant constraint would apply to sellers, as some countries are expected to have emission levels as low as 70-80% of their base year emissions – whether it is 1990, in the case of Russia, or another year. 5% of the average between that level and the assigned amount (between 92 and 100% of base year emissions) would be much lower than the assigned amount surplus. We estimated this amount to be 190 $MtCO_2$, whereas the surplus would amount to more than 1 $GtCO_2$ according to the WEO 2000.[61] Sellers would need to demonstrate that other reductions are the result of specific measures, which would delay their ability to transfer these units and probably add to the cost of transactions.

The Bonn agreement retained supplementarity as a principle but does not include concrete ceilings on the use of the mechanism.

61. See Chapter 10, IEA (2000): World Energy Outlook 2000, International Energy Agency, Paris, France.

Several modelling studies have evaluated how the ceilings proposed by the EU would affect the economics of the Kyoto agreement. They would make two important differences. The restrictions on demand would dampen the market and lower the international price – but also increase the domestic cost of reductions, as the cheaper alternative is being reduced. At the same time, supply from Annex I Parties is also restricted. If all the supply were capped (from both Annex I and non-Annex I Parties, as these can participate via the CDM), the resulting excess demand would increase prices. Since supply from CDM is not constrained, the effect is uncertain. But the two ceilings would appear to push prices in opposite directions. Models generally find that the restriction on supply would exceed that on demand, resulting in a price increase, as if the buyers backing this proposal had inflicted a monopoly on themselves. The main difference with a monopoly, however, is that sellers also lose, as the higher price does not completely offset the lower volume traded.[62] But the most important point is that the overall efficiency of the trading regime is reduced because the ceiling increases the cost of meeting the overall abatement objective.

These estimates do not cover the issue of the commitments for future periods – would they be more ambitious if less trading were allowed? They also do not address the technology implications of supplementarity, which could reduce future abatement costs by fostering faster technology improvements.

It comes down in the end to a confrontation of two opposite views:

- the need for everyone to curb emissions trends – the EU proposal for concrete ceilings;
- the need to minimise overall abatement cost – the Umbrella Group position in favour of unrestricted trading.

62. *O. Blanchard (2001) "Coûts des politiques de réduction, marchés de droit d'émission: que disent les modèles?" La Revue de l'Energie, N.523, January 2001. A.D. Ellerman and Ian Sue Wing (2000) "Supplementarity: an invitation to monopsony ?" Report No. 59, MIT Joint Program on the Science and Policy of Global Change.*

The Risk of Market Power

Two types of market power are usually identified in relation to emission trading:[63]

- capacity to influence the transaction price of traded permits ("cost minimising" or "profit maximising manipulation");
- "exclusionary manipulation", by which a commodity producer hoards permits to prevent market entry by competitors.

Under "exclusionary manipulation", a firm that holds a significant share of tradable AAUs decides to hoard them in order to exclude other firms from its market. This may not be a significant problem with international emission trading. If companies participate, the market will cover a broad range of different activities. A new entrant in a sector covered by a domestic trading regime would have access to AAUs from companies outside its own sector. These entities would have little interest in hoarding their tradable AAUs, as they do not compete on the same market as the new entrant. If many sectors and firms are allowed to trade nationally and internationally, exclusionary manipulation seems unlikely.[64]

The risk of market power arises more from the fact that the single action of certain countries (e.g., countries with emission targets above their projected emissions) could greatly influence the supply side of the market in a way that would minimise their cost of compliance, at the expense of other countries. This issue was addressed by analysing the CO_2 mitigation cost information provided by the OECD GREEN model.[65] The study estimates the economic losses that would result from monopoly power that could be exerted by the Russian Federation and Ukraine (referred to as Commonwealth of Independent States in

63. See Box 5 in OECD (1999): Action Against Climate Change – The Kyoto Protocol and Beyond. OECD, Paris.

64. Westkog (1996) explains that in the case where governments, not firms, would be the primary traders, potentially conflicting interests by different firms within each country would make it difficult for governments to arrive at any effective exclusionary market manipulation.

65. OECD, 1999.

that paper, or CIS): these two countries are likely to hold the vast majority of AAUs for sale over 2008-2012. The model's estimates should be read as the maximum potential losses that could be incurred.

For monopoly power to be possible, trading by the CIS would need to be centralised (e.g. by setting up a cartel).[66] Two other critical assumptions underlie the model's estimates: trade by other Annex B countries is not centralised through governments but carried out by individual firms. Second, the CIS does not take into account the effect of its market power on energy prices and its terms of trade – Russia's strategy may be revised if its energy markets suffer from its monopolistic behaviour on AAUs. With these caveats, the results are as follows:

- By 2010, the price of AAUs would be about 20% higher than under the competitive scenario (US$ 91 per tC versus US$ 75). The CIS would be able to charge a price for AAUs 178% above its marginal cost of reduction;
- The CIS would reduce its emissions by less than it would have under the competitive scenario, and other Annex I Parties would achieve more reductions domestically, at higher cost;
- Market power would reduce the gains from emission trading by about 20% in 2010, for OECD countries, compared with a non-monopolistic, perfectly competitive market.

An earlier IEA paper demonstrated that market power could be mitigated by a number of factors:[67]

- the devolution of assigned amounts to companies is likely (at least for buyers) and this would make collusion more difficult;

66. *With trading by multiple entities, no single seller could influence the market (Bohm, 1998), unless they form a cartel.*
67. *Baron (1999): Market power and market access in international greenhouse gas emissions trading. IEA Information Paper, International Energy Agency, Paris.*

- there could be more competition among countries with monopoly power than assumed by models – e.g. Russia and Ukraine;
- potential sellers may be interested in attracting mitigation projects, beyond the mere sale of available AAUs. Project-based reductions would require detailed cost analysis, which should generate a more cost-reflective pricing of traded units;
- the supply of emission reductions from the CDM could undermine significantly the bargaining power of potential monopolists (which is not taken into account in the OECD analysis);
- exerting market power may be dangerous when future commitments remain to be negotiated: it could be sanctioned later.

What is the solution if a country or region could dominate the market? Several studies[68] find that trading by companies would greatly minimise the risk of market power.[69] The risk stems mainly from centralised government trading based on the allocation of emission objectives to governments, and the international agreement does not commit governments to set up domestic trading regimes.

Private Sector Participation

As we have already showed, the potential role of private sector companies (known as "legal entities" in the Protocol[70]) in this market is an important issue. Why would they be interested in participating? First, the largest single emission sources in Annex I Parties are large companies that will eventually carry some of the burden of reducing emissions. Some have argued that if they have to undertake measures to reduce emissions, they should have access to the cheapest available options so as to minimise costs and stay competitive. In theory, the

68. OECD (1999) and Bader (1996), following Hahn (1984). See also Bohm, 1998.

69. Mocilnikar (1998), in his theoretical review of tradeable permit systems and market issues, demonstrates that the introduction of forward trades would also lower the opportunity for market manipulation.

70. Entities cover not only private sector companies, but other potential participants that are not Parties, including public companies, non-government organisations, etc.

flexibility mechanisms offer the cheapest options. For this to be practical, governments need to allocate part of their objective (assigned amounts) to these entities, with an obligation either to meet this objective, or buy additional AAUs to cover excess emissions. In return, lower emissions would allow them to sell excess units on the national or international markets. The more participants on the market, the lower the risk of market power and the higher its efficiency.

To make this happen, governments would have to go through the difficult process of allocating the burden. Considerable bargaining would be involved, since allocations would determine the total cost of mitigation for individual companies. Allocations under the US SO_2 allowances programme resulted in about 40 different formulae that reflected various considerations such as earlier efforts to reduce emissions or the desire to preserve local production of high-sulphur coal.[71] Expanding an emission trading regime to more than one sector, in more than one country, with very diverse energy price and industrial structures, production methods and different emission objectives adds a great deal to the complexity of designing a fair and equitable allocation. In fact, what may seem "fair and equitable" for a given sector across countries – e.g. the power generation industry – may not be feasible at all for individual countries, as it would have varying repercussions on the burden of other sources in these countries.

For example, assume that the power industry in one country had already reduced emissions. After discussion with government, its allowed emission level is more generous than the power sector in a neighbouring country, which has much higher GHG emissions per kWh. To offset the lower target for the power sector, pressure on other sources such as transport must be stronger for the former country, and weaker for the latter country with a higher target for power generation. In short, correcting for existing differences could introduce the need for other corrections – and with it, possible distortions of competition.

71. Cros C. (2001) "L'expérience américaine des permis négociables pour lutter contre la pollution de l'air", La Revue de l'Energie, janvier 2001, No. 523. Paris, France.

However, both sides have an interest in establishing an affective international regime: governments because this helps them to meet their targets, and sources because it reduces the cost of meeting targets. The equation is simple: emission trading minimises cost and cannot go ahead without some kind of allocation. Emission trading has another big advantage: it equalises the marginal cost of reductions across sources, whereas the marginal cost would vary between industries operating in different countries in the absence of trading. This is recognised in the recent report of the European Commission working group on flexible mechanisms:

> *"Well designed emission trading should level competition within the EU in a way that other instruments may not be able to do, because each and every company in the trading scheme faces the same carbon market price."*[72]

By taking a quantity-based approach, Parties to the UNFCCC have implicitly decided to allocate emission targets within their countries. This allocation may not always translate into a firm obligation for each source – an impractical option for car-users! – and a GHG trading mechanism is not necessarily suited to the institutional and economic structures of all countries.

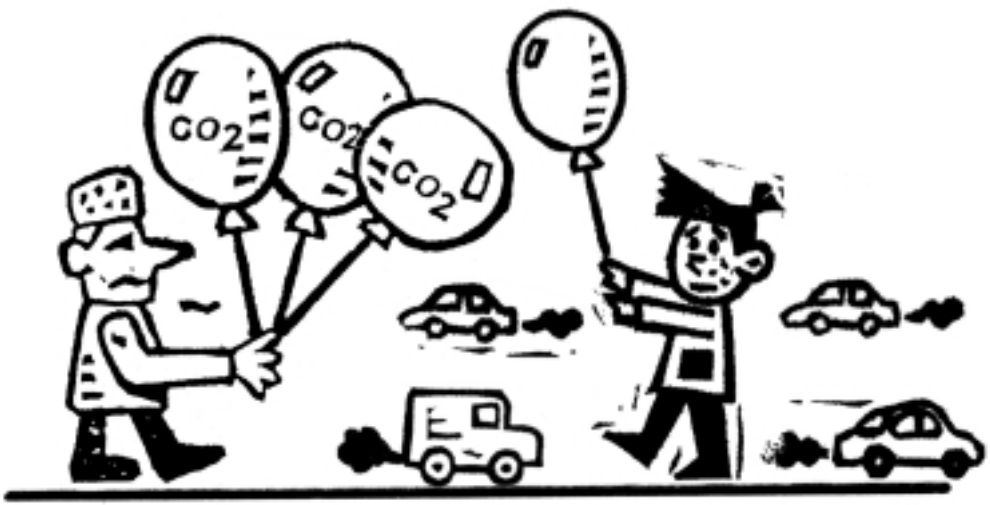
In domestic policy terms, the regulatory framework would need to extend beyond target setting. Countries, not companies, are responsible for meeting the Kyoto objectives. Even if a government devolves part of its assigned amount to companies, it remains responsible if the country does not comply. Emission trading by companies carries the risk that a country could be put out of compliance. Trading by companies may be perfectly legitimate in itself – for example, they may have excess AAUs to sell because they are above their allocated target – but their government may be out of compliance at the same time and the companies' sales may aggravate the situation. Access to the

72. European Commission (2001): Final Report: ECCP Working Group 1 "Flexible Mechanisms". ENV-E1 – Climate Change. Page 3, paragraph 6.

international market could become a fairly thorny issue in negotiating the rights and duties that come with the allocation of emission objectives. The issue has been brought to the fore since the decision in Bonn that AAUs should be set aside in a reserve to prevent overselling. This forces governments to look more closely into the question of companies' access to the international trading system.

It is rather unlikely that governments would allocate the whole of their target to the private sector: some entities are not equipped for this – in particular households and small enterprises. Governments themselves could also acquire units from the international market, if the less binding measures applied to some sectors were not delivering the intended reductions. This implies that compliance of sources which have devolved targets needs to be monitored, and that compliance with national goals must be enforceable (e.g. with financial penalties). Their activity on the international market would not then need to be scrutinised as closely.

In summary, negotiating the rights and duties that come with the devolution of emission by governments objectives is likely to be complex and controversial.



As recognised in Bonn, the participation of entities based on devolved targets is generally perceived as a natural evolution, even if governments remain responsible for compliance and would also trade when necessary. Entities trading would also increase liquidity and reduce the risk of market power, as mentioned earlier.

A Complex Regulatory Framework for a Simple Policy Tool?

Timely inventories, registries for international transactions, other rules such as the reserve – not to mention rules for other flexibility mechanisms – may seem complex compared with the simple idea of emission trading. But trading is for a specific and important purpose – to help the international community reduce emissions. It is therefore crucial that trading preserve the environmental integrity of the Kyoto goals. Safeguards are warranted, at least in the beginning, when confidence in the system needs building up, and must include an explicit framework for dealing with non-compliance.

A strong non-compliance framework would encourage countries with emissions higher than their objective to acquire emission reductions from the market. It would also prevent the transfer of AAUs that lead a country into non-compliance. The restoration rate agreed by Parties in Bonn may play that role, but it could make it possible for Parties to borrow from their future commitment – albeit at a non-negligible "interest rate" of 30% over five years. Absent any financial penalty, the reserve may be a necessary complement to prevent abuse of the trading system – and ensure its credibility as an international co-ordination mechanism.



FROM PERFECT MARKETS TO REALITY: THE IEA SIMULATION

An understanding of how international emission trading might work in the real world can only be obtained by putting it to a practical test. Models are helpful up to a point, but they assume perfectly rational behaviour, and cannot reflect real world political considerations and uncertainties. In 2000, the IEA launched a simulation of international emission trading with countries as the participants.[73] The simulation was intended as a learning tool for governments, as well as a test of the trading framework proposed under the Kyoto Protocol.

Emission trading had been tested in market simulations prior to the one presented here.[74] Bohm (1997) organised an experiment among four Nordic countries before emission trading was included in the Kyoto Protocol text; other simulations at country-level have been performed based on the Kyoto outcome, but without taking into account some real world features of the Kyoto objectives.[75] Other simulations focused on particular sectors or companies, and left aside the role of governments in emission trading under the Protocol.

The framework and rules for the IEA simulation are described below. The chapter then analyses the outcome, including the development of the market, and the range of behaviour patterns observed. It concludes with an assessment of the realistic outcome that may be expected from an international emission trading regime. The simulation focused on the role of governments, and was set up as far as possible to reflect the conditions agreed under the Kyoto Protocol.

73. The simulation described in this chapter was made possible by voluntary contributions from the governments of Australia, the United Kingdom, the United States and from the European Commission.

74. Including the Eurelectric simulation completed in 1999, covered in chapter 3.

75. See Carlén (1999), Hizen and Saijo (1999).

Table 6 shows the participants. 17 Annex B Parties were represented. Two countries – Australia and Canada – devolved part of their target to private sector participants. Some countries were represented by other entities – for example, the IEA represented a group of countries with economies in transition.

TABLE 6

Simulation Participants

Label	Simulated Country	Label	Simulated Country
AUS	Australia (government)	FRA	France
AUS1	Australia (private sector)	HON	Hungary
AUS2	Australia (private sector)	ITA	Italy
AUS3	Australia (private sector)	JAP	Japan
AUT	Austria	NET	Netherlands
CAN	Canada (government)	POL	Poland
CAN1	Canada (private sector)	RU	United Kingdom
CAN2	Canada (government participant as private sector)	RUS	Russian Federation
		SWI	Switzerland
DAN	Denmark	TCH	Czech Republic
DEU	Germany	CDM	IEA participant for Clean Development Mechanism projects
EUA	United States		
EIT	IEA participant managing the assigned amounts of: Bulgaria, Romania, Slovakia, Slovenia and Ukraine	REU	European Commission participant managing the assigned amounts of Belgium, Greece, Ireland, Luxembourg, Portugal and Spain

The simulation covered the period from 2000 to 2012, with 2008-2012 as the commitment period in which emission objectives had to be met. It took place over four weeks.

Table 7 shows the emission objective (assigned amount) for each participant, together with their projected cumulative emissions by 2008-2012 if they had taken no action to reduce them (the so-called business-as-usual or BAU scenario), and the gap between the two expressed as a percentage. For example Austria (AUT) needed to reduce emissions by 30% from what they would have been under BAU.

TABLE 7

Assigned Amounts and "Business-As-Usual" Emissions (2008-2012)

(MtC)

	Assigned amount	BAU emissions	Gap		Assigned amount	BAU emissions	Gap
AUS	96.8	138.2	43%	FRA	515.9	610.6	18%
AUS1	135.6	185.0	36%	HON	87.3	88.4	1.3%
AUS2	58.1	77.2	33%	ITA	520.4	650.2	25%
AUS3	96.8	118.0	22%	JAP	1361.0	1774.8	30%
AUT	74.9	97.4	30%	NET	206.7	289.9	40%
CAN	317.8	395.9	25%	POL	575.6	536.9	-6.7%
CAN1	120.6	169.9	41%	RU	698.5	860.8	23%
CAN2	109.6	166.4	52%	RUS	3257.4	2324.3	-29%
DAN	57	89.1	56%	SWI	55.5	67.1	21%
DEU	1057.3	1279.3	21%	TCH	177.9	173.4	-2.5%
EUA	6180.4	8994.7	45%	CDM	NA	–	–
EIT	1238.0	100.7	-19%	REU	731.7	905.5	24%
				Total	**17,730.8**	**20,993.7**	**18%**

Note: Emissions reported under the business-as-usual scenario were projected for the sole purpose of the simulation. They also incorporate "external shocks" that were introduced during the simulation and had the effect of inflating cumulative emissions by a few percentage points. They do not reflect countries' official projections.

The simulation was deliberately not intended to predict the equilibrium price at which AAUs would be traded, nor the exact magnitude of potential savings from trading. Although some real world data was respected (notably countries' energy-related CO_2 emission levels), a fake currency (called mony) was used to encourage participants to develop their own analysis of the relative costs of pursing different strategies rather than rely on the many available estimates from models.

Setting Up the Simulation

Modelling Country Abatement and Trading Strategies

How would countries project their emissions? And how would they work out their abatement and trading strategies to meet targets? To answer these questions, participants used models provided by the IEA to project how different strategies would affect emissions over 2000-2012, and to calculate the cost of these different strategies.

As a starting point, the models provided participants with BAU projections, approximating the real world as far as possible. These were calculated from the energy demand projections for each country (driven by economic growth and energy prices), which were used to calculate CO_2 emissions from fossil fuel combustion. The real world analogy was reinforced by some surprise external shocks introduced during the simulation period, with significant and unexpected effects on emissions. Unexpected changes in GDP growth, variations in the price of oil, or extreme weather could lead to sudden changes in energy demand and hence CO_2 emissions. For some participants, the surprises meant an increase of 40% in the emission gap between projections and assigned amount. Participants could explore the various possible emission scenarios with their models and elaborate precautionary – or worst-case – strategies. The IEA model allowed them to evaluate the relative cost of domestic action compared with emission trading.

The cost of abatement was driven by a carbon value on emissions, reflecting the cost of domestic policies such as carbon taxes: as the value of carbon increases, energy demand and CO_2 emissions are reduced. Participants could change this carbon tax from one year to the next to reflect abatement and trading strategies, or to adjust to surprises in emission levels. Ideally, participants would continuously

assess the marginal cost[76] of their domestic abatement strategies over the period and trade on that basis. A marginal cost lower than the AAU price should trigger adjustments of the domestic carbon value to reduce emissions further and possibly sell the surplus on the market. A higher marginal cost should encourage symmetrical behaviour: lower domestic cost and AAU purchases on the market.

To reflect policy inertia, a change in the domestic carbon tax would only affect emissions in the following year, and participants could not adjust past tax levels.

Rules for the Simulation

The rules used for the simulation were a simplified version of the rules under negotiation in the context of Kyoto (which we examined in chapter 4). Some rules could not be tested because this would have made the exercise too complicated or because a simulation would not have helped in reaching clear conclusions. For example concrete ceilings on the use of trading were not included since the cost information used in the simulation could not reflect the complex dynamics of various sectors' emissions or technological progress (which are at the heart of the supplementarity discussion).

Time Frame

The simulation covered the period from 2000 to 2012 plus one additional year for trading purposes in the end. This was divided into 8 trading sessions covering a year or several years.[77] There was one commitment period, 2008-2012, in which participants had to meet their emission targets.

76. Participants had to go through the following steps to determine their domestic marginal cost of abatement with the model, and hence the trading strategy which they should follow as the simulation unfolded: 1) define a baseline domestic strategy (i.e. a tax path over 2000-2012) which took account of the BAU emission projection and the reduction target; 2) determine the cost of a strategy with a marginally higher tax rate; 3) observe the additional emission reductions and compare the cost of achieving these additional reductions – the marginal cost of reduction – with the AAU price and 4) assess whether acquiring AAUs from the market was cheaper or more expensive than achieving emission reductions at home.

77. The eight periods were 2000-2003, 2004-2007, 2008, 2009, 2010, 2011, 2012 and 2013.

Targets (assigned amounts)

Each participant was given an emission target to meet in the commitment period, as well as the cumulative emissions that it would have by that period if it had taken no action to reduce emissions (the so called BAU scenario). The objectives were consistent with those of the Kyoto Protocol. For example, commitments under the EU burden sharing agreement were used for EU countries and the REU (rest of EU) player. Participants' emission targets were expressed in terms of an assigned amount of carbon-equivalent emissions (million tonnes of carbon or MtC), translated into AAUs of 1 MtC.

Reporting

The country participants had to report annual emission levels (inventories) and net trades by the end of the session in the form of annual reports. These reports had to be available within a year of the year reported on (the simulation required a much shorter deadline than is likely in the real world, where it could take as long as two years to produce reports). No retroactive corrections were possible except in rare cases of inventory mistakes. This meant that participants could not undo past policies based on their observations as the simulation unfolded. This is a crucial real world constraint, which together with uncertainty over future emissions and costs, is absent from the models. The IEA collated and circulated annual reports based on the individual reports. The reports made participants aware of each others' emission trends and compliance prospects, so that assessments could be made of future demand for AAUs.

Compliance

Meeting targets could be achieved either through domestic reductions, or through the acquisition of AAUs. No formal penalty was imposed for non-compliance (it was expected that participants would play correctly). However seller liability was applied as a default principle

(countries were responsible for holding enough AAUs to meet their targets and sellers were therefore responsible if AAUs were oversold). As chapter 4 made it clear, a buyer liability regime would require a much more complex market structure and information on countries' compliance prospects that could not be generated in a simulation of this kind.[78]

Forward trades

Participants could undertake forward trades from the first trading period onward (2000-2003). AAUs traded in that period were for delivery in 2008-2012, although AAU transfers were recorded at the time of the trade.

Currency

A virtual currency, the mony, was used to prevent participants relying on available modelling to project mitigation costs or anticipate the price of AAUs. All price information reported below is entirely based on cost assessments made by participants during the simulation.

CDM

A limited quantity of CDM certified emission reduction units (CERs) was allowed into the simulated market (as we explained in chapter 1, the CDM is another way in which Annex B countries can meet their commitments under Kyoto). The CDM component was deliberately limited, as its mechanics are unknown at this stage and the main purpose here was to test trading. The supply of CERs was based on a simple marginal cost curve. The total amount of CERs put into the simulation was 600 MtC, starting at 10 mony per tC and rising to 50 mony per tC.

78. The simulation could, however, have tested a reserve on AAUs.

Commitment period beyond 2012

It was assumed that a second commitment period, in which further emission reductions would be required, would follow immediately after 2012, although the simulation commitment itself stopped in 2012. AAUs could be banked in 2008-2012 for use in meeting these later targets (in line with Article 3.13 of the Kyoto Protocol). This rule appeared to have had an important bearing on the emission trends and strategies of some countries.

Grace period

A final session was introduced at the end of the period (2013) for those participants who wished to acquire AAUs, either to bank for future use or to cover emissions in 2008-2012. Since inventories and net trades were made public at the end of each trading session, participants knew at the end of the period which countries were not (yet) in compliance, how many AAUs remained in the system, and whether there were enough to cover the needs of countries that were not yet in compliance. Nobody, however, was forced to sell to countries that might need AAUs.[79]

Organising International Trades

An Internet based market (similar to public exchanges for other commodities) was used in the simulation.[80] This was designed to allow participants to trade AAUs in a single market place. For simplicity and efficiency the market used a so-called "double auction" rule in which only the best-priced offers could lead to a transaction. The identity of participants behind each trade was not disclosed.

Participants could also use a set of confidential markets (one per participant) if they wanted to conclude bilateral transactions outside

79. *As banking was an option, the availability of excess AAUs at the end of the 2008-2012 period did not necessarily reduce their price.*

80. *It was originally developed (and modified for this simulation) by the Laboratory for Experimental Economics and Political Science of the California Institute of Technology (Pasadena, USA).*

the exchange. Their identity was revealed on these markets. Transactions on the exchange and bilateral markets were tracked in real time and AAUs were adjusted immediately for both buyer and seller. The country of origin of traded AAUs was recorded.

The public exchange

This market used the so-called "double auction" rule, in which only the best-priced offers could lead to a transaction. Under this rule, the exchange displays two offers at any given time:

- the quantity (in AAUs) and the highest offer (price) to buy;
- the quantity and lowest offer to sell.

Table 8 shows how the mechanism works. At Time 1, there is an offer to buy 2.5 million tonnes (or 2.5 AAUs) at 30 mony per tonne, the highest price at this time. The best offer to sell is for 50 million tonnes at 32 mony. At Time 2, someone has acquired 5.5 million tonnes at 32 mony: only 44.5 million tonnes remain from the previous offer. At Time 3, someone is offering to buy 5 million tonnes at 31.5 mony, which outbids the previous best buy offer of 30 mony per tonne.

Table 8

Illustration of the Simulation Exchange
(AAUs and Mony)

	Best BUY offer	Best SELL offer
Time 1	2.5@30	50@32
event		sale of 5.5 units at 32
Time 2	2.5@30	44.5@32
event	higher buying price – 31.5 – is posted	
Time 3	5@31.5	44.5@32

Note that there need not be a match on price and quantities for a transaction to take place. Traders only need to agree on the price. This

guarantees that the best possible price can be obtained at any given time by whoever is willing to buy or sell.

The bilateral exchanges

The main difference with the public exchange was that offers made on a participant's market could be seen only by that participant, and that the identity of the counter-party offering the transaction was disclosed. Table 9 shows what a potential seller would see if a bilateral transaction (an offer to buy) were issued on its market. The first line shows information regarding possible bilateral trades, the second shows the public exchange information.

TABLE 9

The Public Exchange and Bilateral Market
(AAUs and Mony)

Market	Best BUY offer	Best SELL offer
Exchange	2.5@30	50@32
Bilateral market	10@31 from participant x	—

A seller may be inclined to accept the private offer to buy 10 AAUs at 31 mony, since the best buy offer on the public market is 30 mony. But why would the buyer not go instead to the public exchange and outbid the best buy offer with a price only slightly higher than 30 mony, which is lower than the 31 mony it offers on the bilateral market? In short, there was no advantage in using bilateral markets, under the conditions used for this simulation (which did not include potential real world factors such as the possibility of trading commodities other than CO_2 at the same time). That said, participants did try to obtain better prices than those on the exchange, and sometimes succeeded (it could happen when the participant offering the transaction did not follow developments on the exchange and failed to update its bilateral offer accordingly). This explains why the public exchange was favoured over the bilateral markets, which only traded 13 % of the total volume of AAUs.

The Outcome: Reduced Compliance Cost ... Despite The Uncertainties

All participants traded on the exchange, and they all complied with their emission targets. The overall cost of compliance was significantly below what it would have been using domestic action alone.

Emission Targets Were Comfortably Met

All participants complied with their emission targets. Overall, participants reduced emissions by some 150 MtC below the target of 17 GtC. Most participants met their target by a small margin. 8 held excess AAUs which they sold in the grace period. One atypical participant overshot its target by more than 25%, and came out of the simulation with a large amount of banked AAUs, having met nearly all its target through domestic action (its strategy appeared to be to acquire AAUs whenever they were cheaper than domestic reductions, and to bank them systematically).

Figure 8 shows emission trends over the simulation period against the overall emission target (corrected for the addition of CERs – which allowed participants to emit more CO_2 than the original target – as they were brought into the system).

Early trends indicate an overall emission level in the period 2003-2007 significantly below target. Nearer the commitment period, the addition of CDM credits loosened the emission target.[81] The overall reductions in 2008, 2009, and 2010 together with the addition of CERs more than offset emissions above the target in 2011 and 2012.

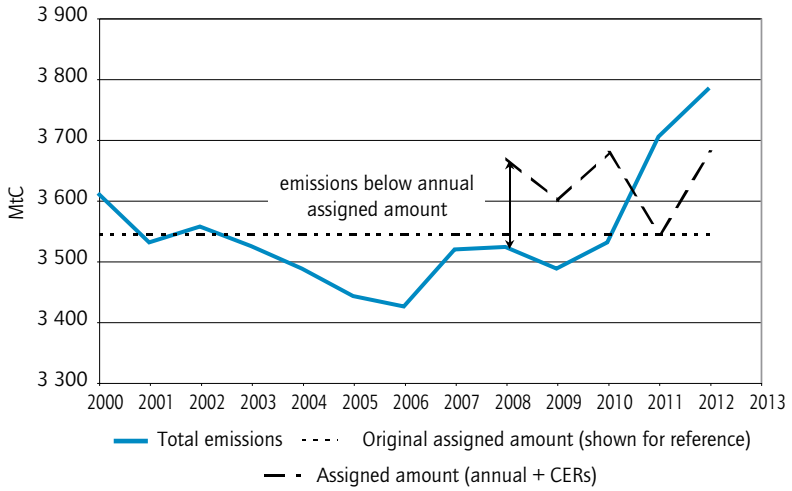
The 150 MtC of emission reductions below target could be banked for future use. But it amounted to less than the difference between 2012

81. This may give the false impression that CDM brought the system in compliance. In fact, CDM credits amounted to some 470 MtC out of net transfers of 2.1 GtC. CDM credits in the simulation therefore accounted for less than 25 % of the flexibility mechanisms' contribution to compliance.

emissions and the emission target in annual terms of about 240 MtC. It would not therefore be much help in meeting the commitments of a future period. If the simulation had included an emission reduction commitment for a further period, participants would have probably reduced emissions still further in order to avoid compliance problems for the future.

FIGURE 8

Emission Trends and Evolution of Assigned Amounts



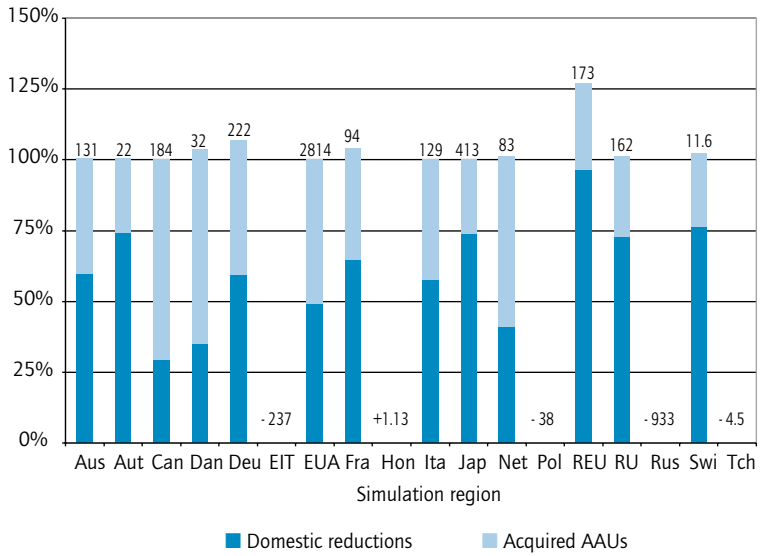
Overall, participants used trading (and CERs) for 45% of their emission reductions. This result is heavily influenced by the behaviour of a few large participants[82] whose weight in overall emissions is significant. Figure 9 shows the mix of domestic reductions and trading of each country and group in the simulation.

Because targets could be met quite easily with careful planning, the absence of penalties for non-compliance in the simulation probably had little influence on the results. But trading activity could have been very different if there had been penalties and a significant risk of non-compliance.

82. EUA, JAP, and DEU.

FIGURE 9

How Countries Met Their Emission Objectives



Note: Each participant's total reduction effort is indicated at the top of the bar, e.g., AUS needed to reduce emissions by 131 MtC in order to meet its national emission goal. Net sellers are not represented here as they met their emission objectives entirely through domestic action.

The outcome for buyers was different from that of sellers. The emissions of most buyers had gone up at the end of the simulation period, whereas the emissions of most sellers had stabilised. Buyers' emissions were nevertheless 15% lower than they would have been without the cap on their emissions. The difference between these emissions and the cap was covered by AAUs acquired on the market. Symmetrically, sellers reduced their emissions by 13% from BAU projections.

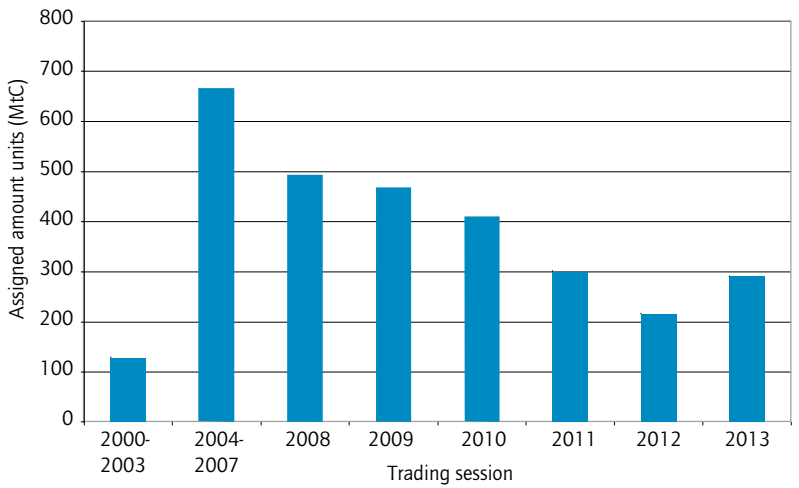
A Stable and Liquid Market Emerged

Figure 10 shows the total volumes of CO_2 traded in each session, along with prices. A majority of traded volumes were exchanged early on, except for the first period, when RUS (the largest seller) had not yet

started to sell. About 60% of total volumes were traded before 2010. In this early stage, participants were testing the price of CO_2, and could reduce emissions at home more cheaply – an early reduction in emissions proved a less expensive alternative than an abrupt increase in carbon tax near the end. Later, as the price firmed up and countries had covered their needs through precautionary early transactions and domestic efforts, the traded volume declined.

FIGURE 10

Traded Volumes



After a first session where significant price volatility was observed, a more stable and liquid market emerged. After 2004, AAU prices declined from 50 to 30 mony per tC, and remained around that level until the end of the simulation. Price variations between sessions can largely be explained by changes in expectations regarding compliance. The price went up when compliance expectations were pessimistic, as participants were pressed to acquire AAUs to comply, and vice versa. In 2009, a lot of trading needed to take place before each participant could ensure compliance. The following warning was issued at the close of trading in 2009:

> *"[...] the emission outlook for the remainder of the commitment period is not as rosy as previous trends indicated. Indeed, due to GDP growth in the OECD Europe region and unexpectedly low oil prices, emissions are likely to be some 3% higher than anticipated in 2011 and 2012. According to projections based on current inventories and the new economic environment, the Annex I participants may be only some 13 MtC below the assigned amount at the end of the commitment period."*

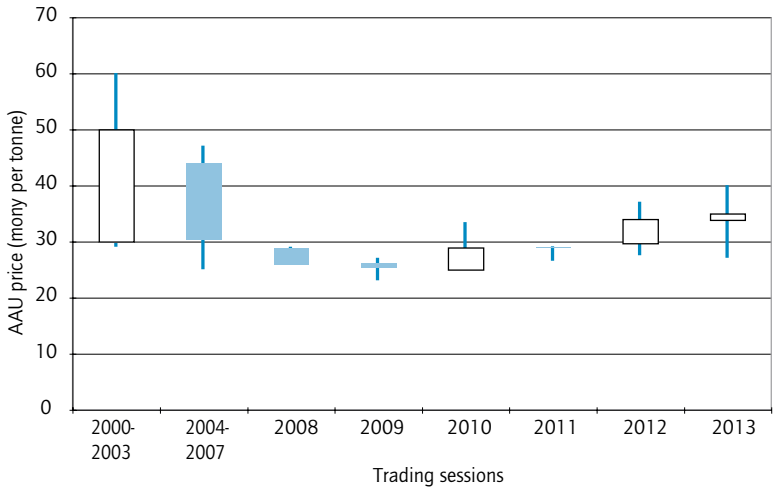
This had a marked effect on the CO_2 price in the next trading session: the average price went from 25 to 30 mony per tC between 2009 and 2010 – a 20% increase. This increase was followed by a release of CDM credits into the market. The 2010 market outlook said that the system was likely to be in compliance overall, although a few participants still needed to acquire AAUs in order to comply with their individual targets – or take domestic measures, but these would prove more costly at that late stage. The upward pressure eased in 2011, with an average traded price of 28.5 mony per tC, but resumed in 2012 and during the grace period in 2013 when the average price of CO_2 reached 35.5 mony per tC.

In summary, uncertain future emission levels and lack of information on mitigation costs explain the wide price variation observed early on (Figure 11). Later, unexpected changes in inventories and their implications for overall compliance increased participants' willingness to pay for AAUs in order to guarantee compliance. Near the end of the simulation, domestic actions to bring additional reductions became increasingly costly. This intensified competition between buyers, and led to a progressive increase in AAU prices from 2009 onward.



FIGURE 11

Price Variations



Note: The dark vertical line indicates the price range in the session (minimum and maximum). The grey or white areas indicate the opening and closing prices: white indicates a closing price higher than opening; grey the reverse. The price climbed during the 2000-2003 session, fell in the second, third, and fourth session, and climbed in all subsequent sessions.

The average price of AAUs over the whole simulation period was 31.5 mony per tC. The average price on bilateral markets was 33.8 mony, that on the exchange was 30.6 mony. As we already noted, bilateral trades accounted for only 13% of total traded volumes. This outcome is not surprising given how the markets were set up. A priori, either buyers or sellers would come out worse in a transaction on bilateral markets, unless the price was exactly the same as for the public exchange. The real utility and influence of bilateral markets was not therefore fully tested.

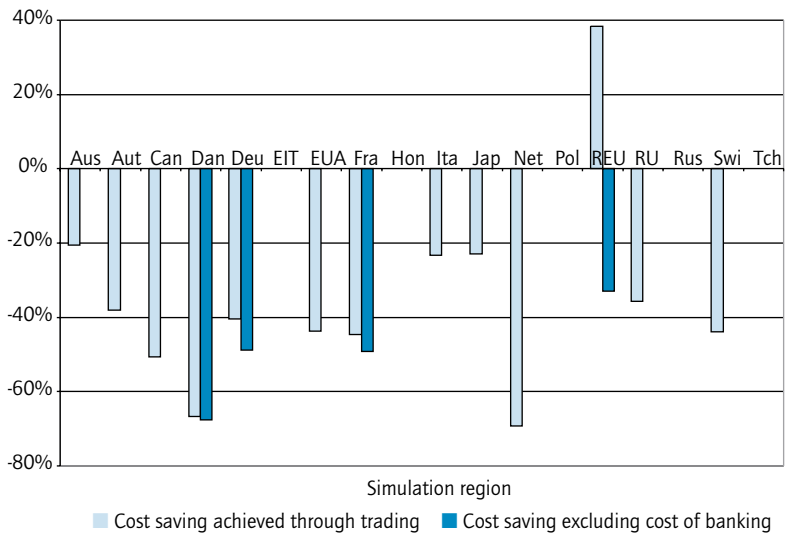
Trading Reduced Compliance Costs: but Could They Have Done Even Better?

Trading reduced compliance costs very significantly, as it gave participants a potentially cheaper alternative to domestic action, which

they exploited. Overall, participants were able to reduce overall mitigation costs by 66% relative to the cost of curbing emissions domestically.[83] Figure 12 shows the savings achieved by participants from trading compared with a purely domestic emission reduction strategy. The biggest savings were made by those countries with the largest gap between the domestic cost of curbing emissions and the price of AAUs. EITs were also significant beneficiaries for a different reason – their emission target was below their projected BAU emissions so they had AAUs to spare, which they could sell at a profit.

FIGURE 12

Cost Savings Achieved through Trading



Note: The figure shows savings with and without the cost of banked AAUs – units that participants held above their emissions at the end of the simulation. We assume that the most expensive reductions relate to the compliance cost for the second commitment period. For REU, if the cost of banked units is allocated to the first commitment period, the region has spent much more than necessary. If not, REU has saved more than 30% on compliance costs with trading.

83. The IEA evaluated, ex post, the total cost of a scenario in which every participant achieved compliance through domestic reductions, and compared it with the total costs incurred in the simulation.



But participants could have cut costs even more overall – by 80% – if they had behaved as economic theory suggests.[84] In brief, to minimise overall compliance costs, participants needed to ensure that their marginal cost of domestic action was the same or below the price of AAUs. If it was higher, the efficient action was to cut back on domestic action and acquire AAUs instead to offset the increase in emissions. On the other hand, participants with a lower marginal cost of domestic action than the price of AAUs had no interest in buying them – unless they anticipated a future increase in domestic costs. They would instead increase domestic action to meet their target, and also perhaps to generate additional AAUs for sale at a profit.[85]

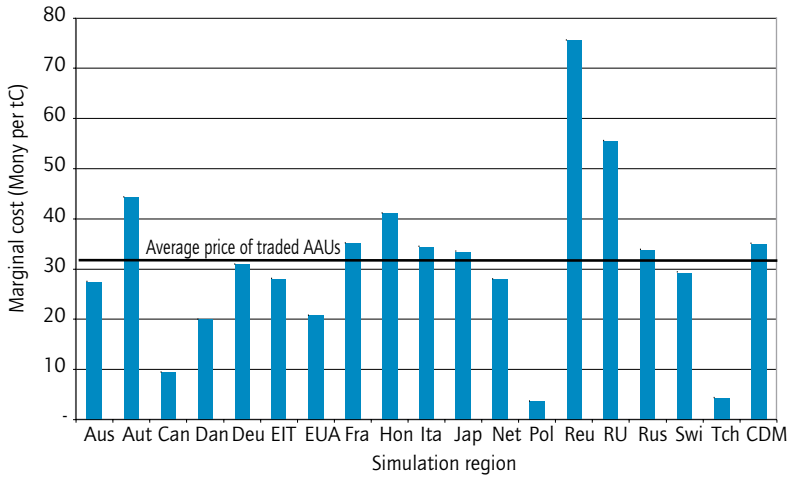
If so, compliance should have been achieved at a marginal cost of about 25 mony per tC. But the average price of AAUs was 31.3 mony – about 20% higher. Participants did not always or uniformly apply a marginal cost equivalent to the AAU price. This means that not all participants optimised their domestic strategy, as the closer their marginal costs were to the AAU price, the more cost-efficient their abatement strategy. Figure 13 compares marginal costs and the AAU price. Any gap between the AAU price and the marginal cost is an indication that further savings could have been achieved.

84. This result was derived by first computing the marginal cost of reduction which, if implemented by all participants, would have resulted in compliance. We then computed the total cost of such a strategy and compared it with the total cost incurred in the simulation.

85. See explanation on the efficiency gains brought by emission trading in Box 2, Chapter 1.

FIGURE 13

Marginal Cost and Price of Traded AAUs



Why this gap between theory and reality? Theory assumes perfect market conditions and a perfect knowledge of future emissions and other factors. The real world is not like that. Participants were unaware of each others' mitigation costs[86] and needed to take early – and irreversible – decisions on domestic policies, as delaying action could greatly increase costs. Trading opportunities were not maximised because of the uncertainty. Many participants adopted cautious compliance strategies: the system generated more reductions than necessary and hence higher costs.

The most important explanation seems to be that different strategies emerged among participants – which are probably a fair reflection of likely real world reactions to trading:[87]

86. *In a regime where private companies would be the primary players, we note that they are unlikely to reveal strategic information about their internal mitigation costs.*

87. *Market power does not appear to be to blame for the relatively high price. Absent significant competition among sellers, large potential sellers could theoretically restrict supply so as to sell AAUs at a price higher than their marginal cost of curbing emissions. But as Figure 13 shows, prices were very close to marginal costs for the two major sellers, EIT and RUS. The double auction probably helped to minimise the use of market power by encouraging price competition between sellers – and by other participants as well.*

Steady policy course

Some participants decided at the outset on domestic abatement policies which they kept in place throughout the simulation, and relied on trading to meet the part of their target that would not be covered by domestic action. In other words they did not adjust their domestic policy up or down to reflect the price of AAUs. In the real world a steady (no change) policy may be well justified. Negotiating domestic measures with various stakeholders is a demanding task, and governments are unlikely to make constant adjustments to reflect the international market. Some policies have domestic environmental benefits that need to be offset against the fact that the CO_2 element may be priced low on the international trading regime. Companies could also find it costly to make rapid changes to their operating methods and physical capital; not all activities can be rapidly adjusted.

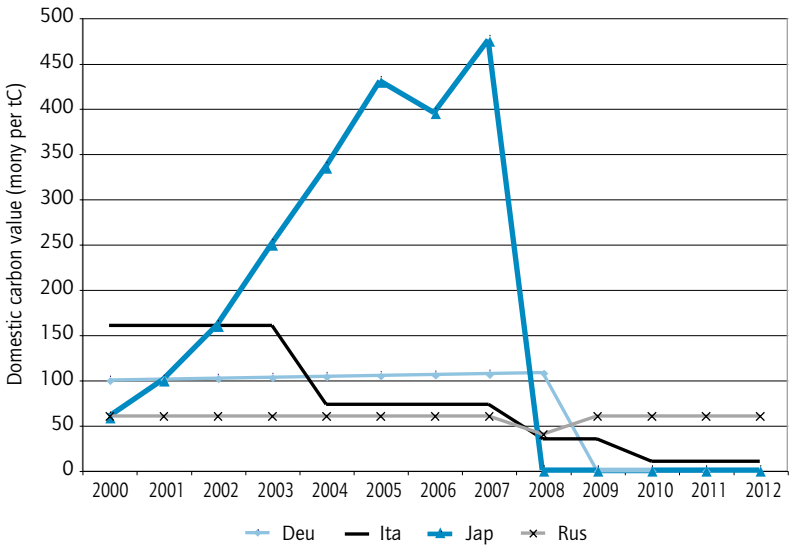
Adjusted policy

Another strategy was to take a cautious approach in the early days (reducing emissions domestically even if trading would have been cheaper), and review whether to adjust later if the price of AAUs came down. One participant, DEU, simulated a radical policy change in 2009, which brought its carbon tax in that year down to zero. Its overall marginal abatement cost ended up very close to the average AAU price, the sign of a highly efficient compliance strategy – thanks to that radical policy change.

Figure 14 shows other policy routes taken by participants. The AAU price reduction observed in 2008 encouraged JAP to abandon its domestic efforts, and ITA to reduce its carbon tax still further.

FIGURE 14

Evolution of Domestic Carbon Taxes



Note: These costs are not equal to the marginal cost of reductions for the country as a whole; they indicate the equivalent of a tax that would be applied by emission sources in these years.

All trade or no trade

One private participant did not cost its emissions at all and relied entirely on trading, which was reflected in an overall marginal cost for its country that was much too low (see CAN in Figure 13). At the other extreme REU achieved nearly all its target domestically.

Traders and risk takers

Some participants engaged in pure trading activity, buying and selling AAUs to make a profit (as well as to meet their target). This turned out to be a successful strategy for some, as they managed to reduce the net cost of AAUs purchased for compliance. Taking these profitable trades into account, it cost FR and SWI respectively 23 and 4 monies to acquire an AAU on average, compared with the average price of 31.3 mony. This trading for

profit can be distinguished from the trade in AAUs for compliance by a simple observation: 2.9 billion tonnes were traded of which only 2.1 billion were actually transferred from one participant to another.

Banking AAUs for the future

The extent to which AAUs were banked was a crucial factor in some participants' cost of compliance. Some players assumed that all the costs of compliance would be borne in the period covered by the simulation, when banked AAUs and their costs could be rolled over into a further commitment period that was assumed to follow. On this assumption REU spent much more than needed if the goal was to comply with 2008-2012 alone. But this is not necessarily a costly strategy if banked AAUs could avoid the higher cost of future reductions. Figure 12, shown earlier, highlights the savings achieved through trading with and without the cost of banked AAUs, for those participants who banked.

In 2011, overall compliance was certain. One Australian participant expected a price drop near the end, on the assumption that all participants would sell unused AAUs, and that there was no point in banking AAUs as the cost of compliance for a future commitment period was uncertain. It therefore sold some 130 MtC worth of AAUs in 2011, hoping to buy them back at a lower price later. But the price did not fall, as participants that had generated or bought more AAUs than they needed were ready to bank them if the offered price was below their mitigation or acquisition cost. The same 130 MtC were sold back to the participant at a higher price than the original price. This transaction slightly increased prices in the last period, and resulted in a significant trading loss for the participant.

Rational sellers

One very particular set of participants were those who had BAU emission projections below their target – essentially, countries with economies in transition under the Kyoto Protocol. These participants

already had excess AAUs which they could sell without missing their target; but they introduced domestic measures to reduce their emissions even further so as to create headroom for additional AAU sales. The early emergence of a price for AAUs provided the necessary signal. EIT, HON and RUS reduced emissions by 14, 13, and 15% below BAU projections. These participants tried to keep their marginal abatement cost close to the price of AAUs, which assumes that their domestic policy was adjusted to reflect these prices. POL and TCH were less aggressive, with emission reductions of 5 and 3%.

In the real world, decisions to create additional AAUs for sale may either be encouraged or tempered by other factors. For example transaction costs may limit the profits to be made. But a domestic emission trading regime may encourage action, by relaying the international CO_2 price directly to companies (taxes and regulations, which may be less easily adjustable, would not have the same helpful effect).

Companies trading

Two country participants devolved assigned amounts to private companies who acted independently of their governments. There were no constraints on what they could do, apart from producing inventories as a contribution to the countries' national inventories. This is similar to the real world requirement to produce inventories under the Protocol. In fact, setting emission caps on companies, which in turn necessitates close monitoring, can contribute to more timely and accurate inventories at the country level, as companies need to produce their own inventories to demonstrate compliance.

Questions were raised about policy coherence if there is no constraint on what companies do to achieve their targets. Would it make sense for a company to acquire AAUs from the international market when they may be available on the domestic market? The response of companies in the simulation was that they wanted to get the best possible price, and that the public exchange was the place where this was guaranteed.

Governments, not companies, are responsible for compliance with the Protocol's emission objectives. Yet countries did not control or limit their companies' trading activity in the simulation. But they had to consider the possibility of having to acquire AAUs from the market if the country was pushed to the fringe of non-compliance as a result of a company's mistake. This risk emerged when one of Australia's players sold all its AAUs in a speculative move. While this risk was taken in a situation where the market was liquid enough to supply AAUs when the participant needed them, this may not always be the case in the real world. Thus, while no control of private company activity proved necessary, there may be some merit in a government AAU "buffer" that would hedge the country against non-compliance – a possibility that was raised by some participants.

We also note that companies and countries alike were subject to a multi-annual emission objective, spanning 2008-2012. In order to produce country inventories, governments collected emission inventories and trading reports from their companies on an annual basis. They could monitor companies' progress towards meeting domestic goals. Yet some countries are proposing to adopt annual objectives as a more systematic way to ensure compliance for the country as a whole. This would have constrained some players in their trading decisions during the simulation, but further conclusions in terms of compliance costs are less straightforward and cannot be drawn from a single exercise.

Lessons For an International Trading Regime

The simulation aimed to reflect the real world as far as possible – in particular, uncertainties and policy inertia. However, its very nature implies caution in reaching conclusions for real world emission trading. That said, some important lessons can be drawn.

What Kind of Market Can We Expect?

Price variations and policy inertia

The simulation, like its predecessors, showed that the international price is likely to vary. It also highlighted other factors that would prevent the use of trading to achieve an optimal outcome. For one thing, domestic policies cannot be constantly adjusted to reflect the price of internationally traded AAUs. A carbon tax, for instance, could not be adjusted easily. Recent experience shows that energy users may not accept abrupt energy price increases. Many regulations are designed to stimulate investment in technological progress, and policy stability is essential for success. Policies can also be motivated by other objectives in addition to reducing emissions: a change in carbon prices would not warrant an equivalent adjustment in policy. At the same time, some participants did not hesitate to implement radical policy changes to lower their domestic costs, an approach that may not be feasible in real world conditions. Domestic emission trading, with access to the international market, would make it easier for sources to react to international prices, but such regimes are unlikely to apply to all countries and all sources. Private sector activities are also based on medium- to long-term strategies and cannot change as quickly as is sometimes assumed.[88] All of this does not alter the basic observation, confirmed in this exercise: countries with emission caps can reduce compliance cost significantly through trading, but not by as much as the models projected.

The timing of inventories

Emission inventories were available at the end of each year in the simulation. In practice, governments may not know their precise emission levels when they have to make trading decisions. The completion of inventories required by the UNFCCC lags behind actual

88. As shown in the first Eurelectric simulation.

emissions by at least two years. Countries may still find themselves trading AAUs relating to the first commitment period in 2013 and 2014, when the price signal would no longer have an effect on emissions in the 2008-2012 period! This would undermine the efficiency of the regime, even if futures contracts could help reveal participants' expectations earlier on. The uncertainty observed in the early years of the simulation and related price variations could also continue. This would increase the challenge of adjusting policies to international prices, which is what some countries want to do in order to minimise compliance cost.

Market players would develop alternative sources of information that they can use to gauge countries' emissions in advance of the official inventories. For instance, the IEA energy balances and the publication of energy-related CO_2 statistics, based on official energy data, are released ahead of the full inventories.[89] However, some uncertainty may remain on inventories for years up to 2011, but the information on which trading in the first period commitment will be based should be fairly robust. Of course, this does not prevent exogenous shocks and emission increases that could compromise countries' compliance prospects.

Beyond 2012

Most participants did not incorporate potential future commitments in their strategies (probably because they were given no clear indication on how to do so). It is worth recalling that as a result of their use of trading for compliance, buyers emitted more GHG than their initial assigned amount. If the overall prospect is for a tighter regime, policies undertaken in the first commitment period may be more aggressive. Banking may become a much more attractive strategy and prices would come to reflect the expected cost of compliance in the second commitment period, as AAUs banked from the first period would be valid for compliance in the

89. Production indices for agriculture and fertilisers could also provide information on CH_4 and N_2O emissions.

second. This argues in favour of an accelerated process to negotiate obligations for future commitment periods.

Mitigation policies in countries with economies in transition

Trading encourages countries with assigned amounts higher than their emissions to reduce emissions below BAU projections, as further reductions can be sold on the market: such behaviour was observed in the simulation. But choices that are less rational from a climate change standpoint could also be made: these countries could turn their back on aggressive mitigation policies knowing that compliance with Kyoto emission goals is almost certain without any effort. Although they are assumed to have significant potential for CO_2 abatement at low or even negative cost,[90] exploiting that potential requires an effective regulatory framework and significant investment. An international price for carbon is essential to encourage action, but may not be enough to generate the necessary political will.

Governments as traders

The national marginal cost of reduction was not difficult to determine with the help of the model used in this simulation. Companies with devolved assigned amounts will probably develop tools of their own to evaluate mitigation costs – a complex task given the many uncertainties that affect these costs: energy prices, interest rates, market developments, etc.

Assessing the national marginal cost of emission mitigation could become a daunting analytical challenge for governments, the more so as they look beyond 2012. For example, the models used here showed that the level of the domestic carbon tax is not a perfect indicator of the marginal cost of abatement, an assumption that is nevertheless

90. Russian economist Igor Bashmakov once described Russia as "the Saudi Arabia of energy efficiency" (Chandler, 2000).

common in global modelling.[91] Other factors include the local environment and competitiveness benefits that arise from reducing domestic CO_2 emissions.[92]

Rules for Trading

The simulation was not designed to test rules related to eligibility, market design, liability, non-compliance measures, registries or supplementarity issues, although some observations can be made from the rules which were chosen.

The market design adopted – a public exchange – encouraged price competition between both buyers and sellers. Participants used the observed price range to determine the cost to be borne by their domestic sources. The system was efficient and compliance costs were significantly reduced. Such organised markets would be desirable for emission trading under the Protocol.

The exchange used here kept track of all transactions with the equivalent of an international registry, so that the balance of the whole trading system could be checked in real time. This is an ideal regime, as it combines financial transactions and the transfer of AAUs from the seller's account to the buyer's. The links between a system of national registries and the commercial AAU transactions will require some careful planning before such an airtight regime can be achieved.

Seller liability would help to generate an active trading regime: it would guarantee that all traded AAUs are valid for compliance and encourage healthy price competition, as the price would become the only discriminating factor in transactions. But the simulation has

91. A tax would have significant macro-economic effects. Its marginal cost to society may be very different from the tax level once these effects are taken into account. The cost and benefit of other policies with a less explicit cost than a tax would carry a marginal cost that is even more difficult to assess.

92. This factor is ignored by most analytical tools – macro-economic models or models based on technology inventories and optimisation. See IEA (1998): Mapping the energy future, for a discussion of energy modelling and climate change policy.

provided no information on the risk of countries selling more AAUs than their emissions would allow, a concern that led to the adoption of the reserve rule in Bonn.

In Summary

The simulation complements the insights that can be obtained from modelling results and from the discussion of rules for an international regime:

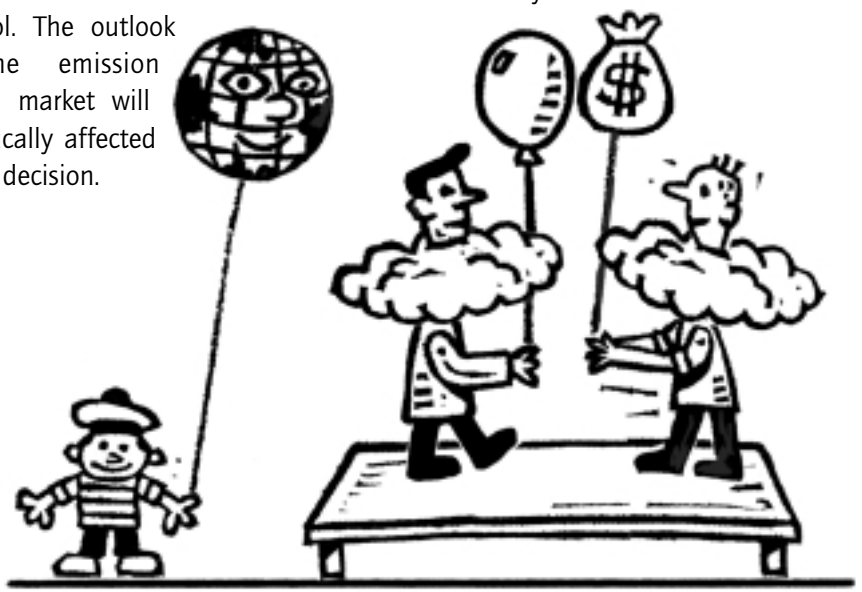
- Emission trading can help cut the cost of meeting GHG emission goals significantly, but not as much as models project, because of likely policy inertia at country level and the price uncertainty that can be expected. Some of the efficiency gains showed by global economic models are theoretical;
- Trading by private companies based on individual caps could help to bring the countries' marginal cost of reduction closer to the price of AAUs. Other domestic policies may be less flexible;
- An emission trading market could encourage further emission reductions in countries with low cost of abatement – especially EITs – provided a price signal emerges quickly. But ambitious policies are needed in such countries if they are to sell additional AAUs;
- Timely inventories and trading reports are essential to market stability;
- An early decision on emission constraints after 2008-2012 will provide critical information for the development of the market in the first commitment period;
- International emission trading could accommodate a variety of domestic policy choices. Because governments are likely to rely on

a range of policy instruments, assessing the marginal cost of reductions for a country will prove a daunting task. But this is crucial information for governments if they are to participate efficiently in international emission trading.

GLOBAL PARTICIPATION IN EMISSION TRADING

Climate change is a global issue, but the Kyoto Protocol only applies to industrialised countries. However, the flexibility mechanisms of the Protocol, not least emission trading, do provide a powerful incentive for developing countries to join in, if the international price of carbon is higher than the cost to them of reducing emissions. There may be other advantages: it is often argued that developing countries have a significant potential for energy efficiency improvements, which could benefit their own development as well as the global environment. However the modalities of developing countries' accession to a trading regime have yet to be worked out.

Global participation also implies that major industrialised countries would take part in trading. But the US has recently announced a decision to abandon its commitment under the Kyoto Protocol. The outlook of the emission trading market will be radically affected by this decision.



This chapter considers both these issues, and the general question of how an international emission trading regime may need to take account of different levels of participation.

Engaging Developing Countries

Climate Stabilisation and Economic Benefits for the Developing World

The UNFCCC aims to stabilise concentrations of greenhouse gases in the atmosphere to avoid dangerous effects on the Earth's climate. This cannot be achieved without stabilisation of global GHG emissions below current levels and requires that developing countries commit, at first to limit the growth in their emissions, and then, ultimately to reduce them. The UNFCCC also recognises that industrialised countries must take the lead, as they have contributed to most of the accumulation of gases to date through the use of fossil fuels for their economic development.

The economic benefits that developing countries would bring to global compliance if they were to participate in a global emission trading have already been highlighted.[93] The OECD compares three different scenarios for global participation, that lead to three different level of GHG concentrations by 2200:[94]

- "550 ppmv", roughly twice the concentration of pre-industrial times;[95]
- "740 ppmv", a doubling of current concentrations;
- "Kyoto forever": Annex I Parties limit their emissions at the levels specified in the Kyoto Protocol. Other countries' emissions are not constrained. Concentration would increase beyond the "740 ppmv" scenario.

93. See the global trading scenarios under Chapter 2.

94. OECD (1999): Action against Climate Change.

95. "ppmv": parts per million by volume, the international unit to measure atmospheric concentrations of greenhouse gases.

A comparison of the global economic cost over a 2010-2050 horizon provides very striking results: 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 they allowed global emission trading.[96] In other words, Parties to the UNFCCC cannot afford not to adopt international emission trading if they are to stabilise the Earth's climate; the cost may otherwise be simply prohibitive.

Alternatives to Country Caps: Options for Developing Countries

The reluctance of developing countries to engage at this stage is explained by the potential cost that emission constraints would put on their development as well as their relatively low contribution to global emissions in per capita terms. The cap-and-trade regime envisioned by Kyoto is particularly difficult for them to accept because it has been directly interpreted as a cap on economic development. Philibert and Pershing explore alternative ways to engage developing countries in efforts to reduce emissions and the compatibility of each option with an international emission trading system.[97] Participation in trading guarantees that developing countries would be able to minimise the cost of complying with their objectives. This work seeks to take account of the risk that developing countries could be given too lax a target to mitigate their concern, which could reduce the environmental stringency of the achieved agreement.[98] They propose three alternatives to the current framework:

- dynamic targets;

96. *Furthermore, most of the scenarios that involve trading deliver net economic benefits to non-Annex I regions, from a scenario where they would take no action to reduce their GHG emissions (OECD, 1999).*
97. *Philibert C., Pershing J. (2001): "Considering the options: Climate targets for all countries" Climate Policy 1 (2001) 211-227.*
98. *Kazakhstan has offered to accede to the Kyoto Protocol, presumably on the same conditions as Russia and Ukraine: stabilisation of emissions at 1990 levels by 2008-2012. According to IEA statistics on CO_2 emissions from fossil fuels, the country's emissions in 1998 were already half of its 1992 emissions (IEA, 2000).*

- non-binding targets; and
- targets on specific sectors.

Dynamic targets directly address the risk that a cap would put an inflexible constraint on growth. Dynamic targets would instead be based on a reference scenario expressed in relative terms, not absolute emission terms. For instance, a country could agree on a certain level of GHG emissions per unit of economic output. With a fixed target, higher-than-expected economic growth would make it more difficult to comply. With a dynamic target expressed in intensity terms (e.g., CO_2 per unit of GDP), the allowed emission level would increase accordingly. Conversely, a drop in GDP – and emissions – would not lead to additional emission permits for sale by the country. This option needs refining, in particular to study how autonomous improvements in energy use should be taken into account in setting future intensity targets. The downside is reduced certainty of the environmental outcome but the big advantage is that it could increase willingness to adopt emission objectives.

The option of non-binding targets is more closely linked to international trading. An emission budget would be defined for willing countries. They would be able to sell any surplus if their emissions were lower than this budget. But they would be under no obligation to buy permits if their emissions were above the budget: in that sense, the objective would not be binding. For this option to work, however, other countries would need to have binding targets. However, a country that sells emission permits under this non-binding option should be subject to the same modalities as countries with binding constraints, including eligibility requirements and compliance consequences. In short, the target becomes binding as soon as the country chooses to trade. It is important to avoid creating situations whereby a country would agree to a non-binding emission level, sell emission permits beyond its capacity and be driven to non-compliance, at the expense of the environment.

The non-binding target is similar to a project-based approach such as the CDM, in which the developing world can participate but is not committed to reduce emissions. However, those that wish to do so can transfer certified emission reductions under the CDM provided that they have adopted an emission limit – the baseline – and have proven that they emitted less than this limit. The non-binding objectives would function in a manner similar to the CDM, but apply at the level of countries and provide "credits" against national policies. This would avoid the transaction costs and uncertainty associated with project-based trading, as emission reductions would not be reviewed on a case-by-case basis. Rather, reductions would be verified by comparing the country's inventory with its target, adjusted for trades. Participation in trading would be facilitated, but would require taking on a quantitative emission objective.

The last option would be for countries to target specific sectors whose emissions are well measured and that offer potential for significant emission reductions. This would work best for sectors where there is limited risk of "leakage" (i.e., where emissions in some parts of the economy might increase as a result of a constraint elsewhere).[99] The power sector could be a good candidate, the more so as developing countries often face stringent capital constraints to improve energy efficiency in existing plants and build new ones to meet their future demand.

The World Energy Outlook projects that $1.7 trillion would need to be invested in developing countries to meet their growing electricity demand between now and 2020. The possibility of trading emission reductions on an international market may tip the balance towards the adoption of cleaner, more efficient technologies for power generation, but also bring some of the capital that is needed for electrification. Those countries that envision energy efficiency as a means of limiting

99. But this option may also turn out to be attractive for sectors that are very mobile internationally, precisely to avoid granting an artificial competitive advantage to producers that move to countries without an emission constraint. Instead of a country-by-country approach, certain activities would commit to such goals regardless of their country of operation.

their future electricity needs could also benefit from the possibility of trading emission reductions based on avoided electricity generation.

Thus emission trading does not constrain the options for emission sources to participate, an important consideration for countries that are reluctant to see their energy and economic policies dictated by others.

In the end, participation by developing countries will depend on the priority they attach to climate change mitigation compared with other pressing development priorities. Options such as those considered here would help to minimise the cost of reducing GHG, and even enable a profit to be made. This outcome is consistently supported by analyses that show how developing countries can gain economically if they participate.

Kyoto Without the US: Market and Policy Implications

Like any other market, the market in internationally traded GHG emission reductions is defined by supply and demand. The US decision to renounce the Protocol has important ramifications for those Parties that decide to remain in it.[100] The American decision of course has a direct impact on the environment. But it will have a major impact on future emission trading as well, since the US was expected to be the largest buyer.

We offer here a preliminary view of how the market may operate under these new circumstances, based on existing models, including the IEA World Energy Model and those reviewed in the WEO,[101] and on

100. The White House (2001): Text of a letter from the President to Senators Hagel, Helms, Craig and Roberts. Office of the Press Secretary. http://www.whitehouse.gov/news/releases/2001/03/20010314.html

101. IEA (2000): World Energy Outlook 2000. International Energy Agency, Paris.

additional model runs. A few simple points can be made before we analyse the new market situation:

- With a sharp decline in overall demand, the price would go down; and, as a result compliance costs for the countries that buy AAUs to comply will also fall;
- There will be even less interest in CDM projects now that this cost is reduced.

The Emission Gap without the US

Now that the US is out of the market, the overall gap between the commitments of the remaining Annex B countries and BAU emissions could be anywhere between –207 $MtCO_2$ according to WEO and +2,307 $MtCO_2$ (MIT-EPPA). In other words, the WEO predicts that there is enough "hot air" to supply the needs of OECD regions. The MIT-EPPA model suggests that Annex B countries could not rely on the emissions market alone, but would still need to engage in ambitious emission reduction efforts. Implications for the emission trading regime are considered in the following section.

TABLE 10

Projected Emission Gaps by Region in 2010
($MtCO_2$)

	WEM	GREEN	MIT-EPPA	POLES
US (for information)	1,729	2,537	2,097	1,702
CANADA	153			150
OECD EUROPE	631	880	1,126	660
OECD PACIFIC	318	495	528	367
RUSSIA	(908)	(440)	(407)	(1,118)
UKRAINE + EASTERN EUROPE	(401)	139	433	(4)
OTHERS (1)		521	627	
Net demand without the US	**(207)**	**1,595**	**2,307**	**55**
(MtC)	(56)	435	629	15

Note: (1) Covers different countries, depending on the model, see WEO 2000 for further details.
Source: World Energy Outlook (IEA, 2000), page 245.

Quantifying a Market Response without the US

What follows assumes that the Protocol enters into force with all Annex B countries, except the US. We consider two extreme scenarios and compare these with a third scenario in which the Kyoto Protocol is implemented as agreed in December 1997 – with the US. In the first extreme scenario, countries could use trading to its full extent.[102] Under the second, countries that have "hot air" to sell decide to manage their surplus AAUs by banking some for use in the second commitment period. We assume that these countries decide not to sell "hot air" AAUs in the first commitment period. They do sell AAUs that are additional to "hot air", e.g. generated through JI.

The World Bank has published an analytical framework which is used here to derive preliminary results from the scenarios.[103] It is based on the marginal cost curves of several models, of which two were selected here, the MIT-EPPA, and ABARE's GTEM models. These models cover all greenhouse gases and therefore give a more comprehensive picture. Various options for sinks could have been included in the analysis, but we have decided to exclude them to avoid a multiplication of scenarios.

Three scenarios are therefore presented as a basis for comparison:

- Kyoto Protocol implemented as agreed in December 1997;
- Kyoto Protocol without the US;
- Kyoto Protocol without the US, and without "hot air."

The results in Table 11 confirm the expected drop in the price of AAUs once US demand is eliminated. Assuming a large amount of "hot air"

102. The agreement on the Kyoto Protocol rules reached in Bonn (July 2001) appears to rule this out. It specifies that "the use of the mechanisms shall be supplemental to domestic action and domestic action shall thus constitute a significant element of the effort made by each Party included in Annex I to meet its quantified emission limitation and reduction commitments..." UNFCCC, 2001.

103. Grütter et al. (2001): Carbon Emission Reduction Trade model. *Grütter Consulting and ETH Zürich, Switzerland, for the World Bank.*

(GTEM model), the price could be reduced from $60 per tonne of carbon to $3 – less than one dollar per tonne of CO_2. MIT-EPPA projects a drop in price of only 45%, largely because it projects a very small amount of "hot air" reductions.[104]

From the environmental point of view, unrestricted trading among remaining Annex B countries could turn the Protocol into another financial-transfer mechanism. There would be *some* value in this as a first step to encourage future GHG emission reductions, but the Protocol would have little effect on *global* GHG emissions during the commitment period. In the GTEM model the Protocol would reduce emissions by 41 MtC annually, from the 3 GtC in the business-as-usual projections for the participating countries. This projection represents an extreme – a large quantity of "hot air" and unlimited reliance on trading.[105] But it supports the argument that the transfer of AAUs from EITs should be limited during the first commitment period. In fact, even selling countries may see some benefits in such a limitation.

If "hot air" were to be completely excluded from trading, reductions would amount to 273 MtC in the first commitment period.[106] However, countries that bank their surpluses would be able to use them in the following periods: what is not emitted now could be emitted later, as these AAUs are released on the market. But refraining from "hot air" transfers would set the market on a different path, with a higher price, and would encourage more domestic reduction efforts by both buyers and sellers.

104. A recent study by Hagem and Holtsmark (2001) comes to a similar result, with a price drop from $55 to $18 per tonne of carbon.

105. Hagem and Holtsmark (2001) find that the contribution of the Kyoto Protocol to the reduction of global emissions would drop from 5.5% globally (12.8% for participating countries), to a mere 0.9% (3.7%), from a business-as-usual scenario. Bernard and Vielle (2001) project a more dramatic outcome, with CO_2 emission reductions dropping from 5.8% to 0.08% without the United States. They stress that the United States would emit even more CO_2 in this scenario, as they would benefit from lower world fossil fuel prices.

106. For reference, GTEM projects that the Kyoto Protocol would reduce Annex B Parties' emissions by 624 MtC from business as usual if the US were also participating.

TABLE 11

Emission Trading without the US – OECD Regions (2010)

	MIT-EPPA (all GHG)			ABARE – GTEM (all GHG)		
Price of traded tonnes ($/tC) (1)						
Kyoto	160.7			60.7		
Kyoto without US	87.5			3.4		
Kyoto without US and without "hot air"	94.9			32.0		
	US	EU	O-OECD (2)	US	EU	O-OECD (2)
Domestic reductions (MtC)						
Kyoto	426	183	161	199	106	53
Kyoto without US	0	128	115	0	10	4
Kyoto without US and without "hot air"	0	134	120	0	68	32
Total compliance cost ($Bn)						
Kyoto	63.2	44.0	20.5	34.6	5.3	10.0
Kyoto without US	0	27.1	13.7	0	0.5	0.6
Kyoto without US and without "hot air"	0	29.0	14.6	0	3.6	5.7
Reductions in compliance cost from the Kyoto scenario						
Kyoto without US	N.A	38%	33%	N.A.	91%	94%
Kyoto without US and without "hot air"	N.A	34%	29%	N.A.	32%	43%

Note: (1) As a basis of comparison, the WEO obtains a price of $118/tC in 2000 dollars. The higher price obtained by MIT-EPPA is explained by the almost non-existent "hot air" in the model. The lower prices in GTEM may come from more CDM transactions (all these results assume a limited contribution from the CDM: only 10% of the emission reductions that a global trading regime would generate in developing countries. Under all scenarios, revenues from the CDM would be affected negatively by the absence of US demand). These scenarios assume perfect economic efficiency. A lower overall efficiency – such as that experienced in the IEA simulation, where prices where 25% higher than optimal – would shift all prices upward.

(2) O-OECD: other OECD countries.

Source: Grütter et al., 2001.

Table 12 shows the financial implications of the two scenarios for the economies in transition. Obviously, the disappearance of a large share of the demand for reductions affects the prospect for financial revenues from trading. Net revenues from trading would decrease by 57 to 96%

for Annex B countries of the Former Soviet Union and 66 to 98% for Central and Eastern European countries. These countries could be motivated to limit their sales. By so doing, they would exert monopolistic power on the market, but they might do so with the tacit agreement of some buyers, if these buyers ultimately agreed not to rely uniquely on trading to achieve their commitments.

TABLE 12

Emission trading without the US – Countries in transition (2010)

	MIT-EPPA (all GHG)		ABARE – GTEM (all GHG)	
Price of traded tonnes ($/tC)				
Kyoto	160.7		60.7	
Kyoto without US	87.5		3.4	
Kyoto without US and without "hot air"	94.9		32.0	
	FSU (1)	CEE(2)	FSU	CEE
Domestic reductions (MtC)				
Kyoto	215	114	213	54
Kyoto without US	159	83	19	5
Kyoto without US and without "hot air"	165	87	135	34
Net revenues from trading ($Bn) (3)				
Kyoto	27.5	8.8	24.1	2.9
Kyoto without US	11.7	3.0	0.9	0.07
Kyoto without US and without "hot air"	10.4	3.5	2.4	0.6
Reductions in net revenues from the Kyoto scenario				
Kyoto w/o US	57%	66%	96%	98%
Kyoto w/o US w/o "hot air"	62%	60%	90%	79%

(1) Countries from the former Soviet Union with commitments under Annex B of the Kyoto Protocol (Baltic States, Russian Federation and Ukraine).

(2) Countries from Central and Eastern Europe with commitments under Annex B.

(3) Exports of tradable permits minus domestic reduction costs to generate them.

Source: Grütter et al., 2001; author's assumptions.

According to the framework used here, self-imposed restriction on sales would somewhat offset the reduction in trading revenues from the "full-Kyoto" scenario. In the GTEM scenario, the drop in net trading revenues would be from 96% to 90% for the Former Soviet Union and from 98% to 79% for other transition countries. In one case, however, where very limited "hot air" is assumed to be available (MIT-EPPA), a restriction on its sale would not offset the reduction in overall revenues. As a result, "hot air" restrictions would, in this rather improbable case, further reduce revenues from emission trading for the FSU countries. Other transition countries would still benefit, however (with a decline in revenues from 66% to 60%).

Under the more probable scenario in which there is a large amount of "hot air", countries that could trade it would gain by restricting their sales, introducing a *de facto* cartel. Again, some OECD countries would not necessarily oppose such a move, as it would ensure that the Parties make more of a domestic mitigation effort – and would still limit the cost of compliance.

Last but not least, all unsold AAUs would remain in the hands of their countries of origin. Under the banking provision of the Protocol, they could sell them in a future commitment period, or use them to offset future emissions growth. In other words, our estimates of trading revenues reflect only sales in the first commitment period (on an annual basis). More sales could occur later on, if a second commitment period is agreed.

A trading regime without the US would have major implications for buyers' cost of compliance. Table 11 shows the reductions in compliance cost for OECD regions, compared to a full-Kyoto scenario. With unlimited reliance on the flexibility mechanisms ("Kyoto without US"), the cost of meeting the Kyoto objectives would drop by 33 to 94%, depending on the model and region. Sales restrictions by EITs would raise compliance costs, albeit not back to their original level. They would be 30 to 40% lower than under a full-Kyoto scenario. This

analysis does not take into account macro-economic effects, including terms of trade and effects on global energy prices, all of which would also affect compliance costs.[107]

A Less Ambitious Objective at Lower Cost

To sum up:

- The international emission trading system will clearly be affected by the US decision not to participate in the Kyoto Protocol, as the US was expected to be the largest buyer;
- The direct environmental impact of the Protocol will be diminished. But so will the price of AAUs. This means that compliance costs for countries relying on trading will be lower than expected. Sellers face less promising, but possibly more realistic, prices;
- Sales restrictions could maintain prices at a higher level, but they are not likely to offset reductions in trading revenues from a "full Kyoto" scenario. On the other hand, restricted sales would not be lost forever, only postponed until a future commitment period. The additional revenues from these sales are not accounted for in our analysis;
- If buyers decide on a strategy of more domestic reductions and less international trading, the AAU price may be reduced even further than under the "Kyoto without the US" scenario;
- The Bonn agreement of July 2001 has defined how much sinks could be used to achieve reductions. This agreement would result in lower overall demand than is projected and a potentially lower price.

107. For instance, Bernard and Vielle (2001) find that Annex B trading without the US would generate a net economic gain to Annex B Parties, as reductions in energy subsidies in the transition economies would trigger welfare gains that more than offset the cost of emission reductions in other Parties.

Allowing Diversity, Preserving Efficiency

International emission trading may well evolve on the basis of different, but interlocking, patterns of participation. Countries could decide to make a commitment that would allow them to take part in trading but not on the same basis as Annex B countries. We have presented some options for future commitments by developing countries. The private sector is also taking action, for the moment outside the framework of the UNFCCC negotiation but as a response to the same challenge: the reduction of GHG emissions.[108] Will several systems develop in parallel, when economic efficiency – and reductions – would be enhanced by participation of all countries and companies in a homogenous market?

Systems that develop independently from each other would need to recognise each others' emission-monitoring systems and ensure the compatibility of their transaction registries. They would also need to accept each others' level of effort – joining too lax a regime may not be a desirable outcome for participants that have invested valuable resources to reduce emissions and see their "assets" devalued by such a move.

The UNFCCC will need to face this issue when new countries express interest in adopting emission commitments. But the problem could well arise sooner. Domestic emission trading systems and private initiatives are emerging rapidly, with the risk of incompatibility. The agreement on rules for the Kyoto Protocol which sets the general architecture for international emission trading among Annex B countries will, at least, facilitate progress among these countries.

108. In 2000, seven companies (Royal Dutch / Shell, BP, Alcan, Pechiney, Dupont, Suncor Energy Inc and Ontario Power Generation) with an overall emission level of 360 $MtCO_2$ announced a commitment to reduce their emissions by at least 90 $MtCO_2$ with the help of trading (The Carbon Trader, 2000). More recently, a number of North American firms has launched a similar system, based on the creation of a GHG exchange ("U.S. VOLUNTARY CARBON TRADING MARKET EMERGING – 25 Leaders from Energy, Industrial, Farm and Forest Sectors to Design New Chicago Climate Exchange" – Press release, 30 May 2001).

A WEEK IN THE LIFE OF AN EMISSION TRADER

Monday, 15 March 2011 ● *A news flash. Germany's 2009 energy balance confirms a real drop in Germany's gasoline consumption. So the decline of the past two years was not caused by the economic downturn. This proves that European transport policy is working. Doing some good for the planet. Let's look at the tape. Bravo!!! The price of carbon has tumbled €1.50 in ten minutes. The market understands. Sandro Biroli calls from Milan to boast about his coup. He had indexed the price of credits from the new heat-and-power plant his company is building in India to the exchange indices. He'll now get more for his firm's money and – he hopes – a whopping bonus. But things could look different tomorrow.*

> *Agence France Presse, Paris – Jean-Yves Larousse, president of the Paris Stock Exchange announces that trades of emission credits have topped 100 million tonnes a day. "No exchange can ignore the carbon market any longer," said Larousse. We hope to launch futures contracts in carbon within six months.*

Tuesday ● *Chat with my secretary Matilda. She was 12 years old in 1999 when we held the first "mock" trading games. Nobody expected what they'd evolve into. What a change! This job has become one of the plums on Wall Street. Profits from emissions markets are saving lucky taxpayers a tonne of money. For years, modellers talked themselves blue trying to persuade bureaucrats that emission trading would work. That it would save the world billions. But the bureaucrats took years to agree on international rules.*

Bloomberg, Ottawa – The Canadian Carbon Exchange reacted today to charges of insider trading by launching an investigation into futures transactions completed just before the release of greenhouse-gas inventories by the UN Framework Convention on Climate Change.

Wednesday ● *Three A.M. A call from our office in Australia. There's mild panic in Sidney about which way the market is headed. They're sitting on 100 million tonnes of carbon that they bought at $25. Monday's price drop could wipe them out. We are watching the market closely and decide to ask $25.5 – and cross fingers... The whole 100 million is gone ten minutes later! Billions of dollars have moved south. Millions of tonnes of "non-emitted CO_2" have headed north. In any event, my colleague in Sidney is happy. So are the countries that bought the credits.*

Reuters, London – Year-on-year net profits of UtilitiX, a major energy conglomerate, fell by 47% in 2010. CEO Sam Utile blamed the huge loss on "careless carbon transactions." The problem, according to Mr. Utile, lay with world weather. "We held a long position for too long. Mild weather in North America and Japan drove carbon emissions to amazingly low levels for two years in a row. There's more carbon credits on the market today than anybody wants. We were forced to sell 50% below what we paid. I'll tell you what I told the shareholders: We have no control over the weather." Wasn't carbon trading about stabilising climate?

Thursday ● *A slow day on the market. Everybody's waiting to see whether a batch of electric-power projects in India will be certified*

under the Clean Development Mechanism. If they do qualify, it'll mean an extra 85 million tonnes of carbon on the market. No one seems to know who's likely to buy them, but they're sure to resurface somewhere sometime soon. Brokers, traders and governments are pinned to climatetradenews.com.

Friday ● Voilà. *Certification for 102 million tonnes of carbon. A bit more than expected. And a 20-cent drop in the carbon price.*

> *Associated Press, Washington – Michèle Cusano, a carbon-trading analyst, commenting on the 20-cent dip in the price of greenhouse gas, emphasised the decisive difference between markets in carbon and the stock market. "When countries agreed to greenhouse emission trading," Ms. Cusano said, "the aim was to reduce the cost of meeting their emission-reduction targets. So everyone wants to see a low carbon price. This is bad news for some market players, but it's great news for the world's climate."*





INTERNATIONAL EMISSION TRADING: WHAT IS NEEDED NEXT?

Bearing in mind that the perfect trading system is probably out of reach in the near term, it is clear that a workable system is possible. The task now is to find the political will to implement it.

Implementing the International Framework...

The Bonn agreement defined the rules for emission trading among Annex B countries. The rules strike a balance between the risk of overselling and the risk of an inefficient market. The principle of supplementarity remains, but countries have agreed not to impose strict caps in the use of trading and other flexibility instruments. Country caps have been clarified, with an agreement on how sinks may offset emissions. These provisions are intended to create a broad "comfort level"[109] around the system for all potential participants, governments and companies alike.

What is needed next? A first requirement is reliable inventories of emissions in Annex B countries, and a system of registries to track AAUs when they are traded. Trading of Kyoto obligations could then begin.

109. A phrase used repeatedly by private sector and government experts that met in March 2001 in Paris to discuss the integration of domestic emission trading systems, under the aegis of the International Emission Trading Association.

... From the Bottom Up

A system is already developing out of national GHG emission trading initiatives. There are already questions about their compatibility. It will not be long before the issue of their compatibility with medium-term architecture provided by the Protocol is raised. For instance, the Danish and British emission trading systems seem to fit well in the broader picture of the Kyoto mechanisms, even if details relating to the international dimension of these systems will need to be clarified in time. For instance, a potentially crucial question for the UK government is how companies with targets that are *not* expressed in absolute CO_2 amounts will be allowed to trade on the international market under Kyoto? Another potential hurdle is the difference in penalties for non-compliance across domestic systems. Economists insist that penalties for non-compliance must be homogenised to prevent a new form of "environmental dumping" – if the international AAU price were higher than the penalty in a country, this country's companies could be encouraged to oversell as they would gain from such activity.

Now that Annex B countries have agreed on their emission objectives, the next job for governments is sharing the burden among sectors and companies at national level. This is not a trivial matter, as it will ultimately define the distribution of cost among companies. Some Parties are pushing for a discussion on how allocation should be made to companies, but it is not clear that a rational framework can yet be found for such discussion:

- Countries have agreed to differentiated emission objectives. In principle these reflect their willingness to pay to combat the threat of climate change, as well as their national circumstances – including the contribution of various sources to their emissions;
- The contribution of large industrial users to countries' emissions varies and has followed different paths over the last decade.

Electricity is a growing source of CO_2 in North America, but has been stable in Europe since 1990. So the required reductions from these sectors would differ across regions;

- Industry-wide standards could also be used as a basis for the allocation of effort. However, energy prices and fuel mixes differ hugely between countries. Relying on a single energy benchmark – such as tonnes of CO_2 per unit of output or value added – to determine industry targets across countries would have widely disparate effects and could be at odds with countries' own targets. A government may not need to demand significant efforts from a sector – if the country's other sources have reduced their emissions more substantially – whereas its energy intensity could be higher than the benchmark;

- An agreement among countries on whether permits should be grand-fathered or auctioned to industry might not achieve very much if the goal is to avoid distortions of competition. Grand-fathering is favourable to sources in economic terms, since they need not pay for the "right" to emit their first tonne, which would be the case if all emission permits were auctioned. According to the OECD (1999), grand-fathering lowers the cost of meeting a given emission level, but is not the best available tool to do so.[110]

At this point, it is important to recall that the possibility of trading AAUs is already a significant step towards reducing distortions of competitiveness. It gives both companies and countries access to a shared potential of reductions at minimum cost.

110. *"This may give a region which grandfathers permits a competitive advantage, relative to a region which auctions permits. However, it must be noted that it is a very inefficient way to achieve this objective: appropriate policy design (irrespective of the allocation mechanism) and targeted use of the revenues raised by auctions are likely to be much more effective tools." OECD (1999): Permit Allocation Methods, Greenhouse Gases, and Competitiveness. ENV/EPOC/GEEI(99)1/FINAL, p.18. It is often argued that auctioning may be preferable for the economy as a whole, because the revenues from permit auctions can be used to reduce distortionary taxes. Several modelling studies confirm this point (see Johnstone in OECD, 1999). Mixes of the two allocation modes can also be envisaged.*

Domestic Policy: the Involvement of the Private Sector

Some parts of industry hope to rely on international emission trading to comply with their emission objectives, especially when they are faced with the alternative of a carbon tax. Apart from industry's own interest in trading, there are a number of arguments in favour of allocating emission objectives to companies and allowing them to trade on an international emission trading market.

Studies have shown that the more small-sized participants there are in a market, the lower the risk of market power, as no single participant would be large enough to corner the market. Companies moreover have a better knowledge of their marginal abatement cost curves than any government may have for all of the country's sources. Companies can elaborate rational mitigation strategies, using the flexibility provided by international emission trading and other flexibility mechanisms. Finally, a system based on companies would relay market signals to companies developing tomorrow's climate-friendly technologies.

It is also easier for governments to enforce compliance by their own companies than to agree on an international compliance regime designed to make countries meet their objectives.[111] Governments would probably impose non-compliance penalties to guarantee companies' compliance with their emission objectives if they allow them to trade at international level.

An international regime will of course include both company-to-company and government-to-government transactions – even if for now countries retain full responsibility for "their" transactions and for reaching national emission objectives.

111. OECD (2001): Kyoto Mechanisms, Monitoring and Compliance – From Kyoto to the Hague. COM/ENV/EPOC/IEA/SLT(2001)9.

Summary

The future evolution of emission trading is uncertain. But the uncertainty relates not so much to the efficiency of the instrument, as to the size of the market. This is because the Kyoto Protocol may not come into force with the original list of participating countries. In spite of an American pull-out, a number of countries are seriously considering implementing domestic emission trading systems in the next few years.

International emission trading has the unique potential to co-ordinate many countries' efforts to reduce global GHG emissions. A variety of studies has shown the important savings that trading could make to individual countries and companies.

Market experiments have also shown that price signals will be even more efficient if they are provided early. Countries should therefore move quickly to establish emission trading at both domestic and international levels.



The energy sector, of all emission sources, needs a market signal soon, because it is ridden with inertia – mostly because of its long lived physical capital. Today's infrastructure choices will affect countries' energy profiles for the next few decades, when even more significant reductions may be called for. A clear signal today could avoid the future cost of changing course. International emission trading can deliver that signal.

GLOSSARY

Annex I: Industrialised countries that have committed to take the lead in reducing greenhouse gas (GHG) emissions, in the light of their contribution to past emissions and the induced rise in atmospheric concentrations of GHG. These Parties aimed to return their emissions to their 1990 level by 2000. Annex I Parties are divided into Annex II Parties and countries with economies in transition (EITs).

Annex II: Industrialised Parties, countries that were members of the Organisation for Economic Co-operation and Development (OECD) as of 1992, including European countries, Canada and the US, Japan, Australia, New Zealand and Turkey. Turkey never ratified the Convention.

Annex B: Annex B of the Kyoto Protocol defines emission objectives (assigned amounts) for most Annex I Parties. Countries listed in Annex B are allowed to participate in emission trading under the Kyoto Protocol.

Article 3 commitments: Emission objectives known as "assigned amounts" under the Kyoto Protocol. These quantitative commitments are listed in Annex B of the Protocol.

Adjusted assigned amount: a Party's assigned amount, plus any acquisition and minus any transfer of AAUs that this Party has realised for a given commitment period. At the end of the commitment period, the Party's emissions should be less than or equal to its adjusted assigned amount.

Assigned amount: emission objectives defined by the Kyoto Protocol for the commitment period 2008-2012.

Assigned amount units (AAUs): Unit for emission trading among Annex B Parties. One AAU is equal to one tonne of CO_2 equivalent. In this book, we use "units" and "AAUs" interchangeably.

BAU: Business-as-usual. Used to describe an emission path without action taken to reduce them.

Buyer: Country who acquired and holds AAUs from another country ("buyer liability").

CDM: Clean development mechanism. The CDM enables reductions generated in non-Annex I Parties to be used by Annex I Parties for the purpose of meeting their emission objectives under Article 3.

CERs: Certified emission reductions. Tradable emission reductions generated by CDM projects undertaken in developing countries, to be certified in order to be transferable.

EITs: Economies in transition, that is to say Annex I countries with economies in transition, including countries from the Former Soviet Union, and from Central and Eastern Europe.

Entities: The Kyoto Protocol distinguishes between Parties – countries or regional organisations that are signatories to the Treaty – and so-called legal entities – private sector and public sector companies. In this book, we use "entities" and "companies" interchangeably.

ERUs: Emission reduction units. Tradable emission reductions generated by joint implementation projects.

GHG: Greenhouse gases. Six gases targeted for reductions by the Kyoto Protocol: CO_2, CH_4, N_20, HFCs, PFCs and SF_6.

GtC: Billion tonnes of carbon (see tC).

$GtCO_2$: Billion tonnes of CO_2 (see tCO_2).

International emission trading: International greenhouse gas emission trading among Annex B countries.

JI: Joint implementation. Mechanism established by the Kyoto Protocol allowing transfers of project-based emission reductions units among Parties with emission objectives under the Protocol.

Kyoto Protocol: Protocol under the UNFCCC that sets legally-binding greenhouse gas emission objectives for a number of industrialised countries, and establishes international emission trading.

Liability rules: Rules established to allocate responsibility where a Party that has transferred AAUs is found in non-compliance.

Mony: A virtual currency used in the IEA international emission trading simulation.

MtC: Million tonnes of carbon.

$MtCO_2$: See tCO_2.

Non-Annex I: Parties that are, for the most part, developing countries, subject to a lighter set of obligations reflecting their less advanced economic development and a lower contribution to GHG accumulation to date.

$: US dollars.

$Bn: Billion of US dollars.

$M: Million of US dollars.

tC: One tonne of carbon equivalent. One tC is equal to 3.67 tonnes of carbon.

tCO_2: One metric tonne of CO_2. One tonne of CO_2 equals 0.273 tonne of carbon.

Overselling: Situation where a Party does not hold enough AAUs to cover its emissions at the end of the commitment period, and has transferred AAUs. The Party has therefore sold more AAUs than it was entitled to.

Seller: Unless otherwise specified, the Party that first issued AAUs on the market, i.e., the issuing Party ("seller liability").

UNFCCC: United Nations Framework Convention on Climate Change, agreed at the Earth Summit in Rio in 1992.

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