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# INTERNATIONAL GREENHOUSE GAS EMISSION TRADING

**Annex I Expert Group on the United Nations Framework Convention on Climate Change**

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## FOREWORD

This Working Paper is one of a series of eighteen studies carried out under an Annex I Expert Group project on “Policies and Measures for Possible Common Action”. The studies were written by the OECD, together with the International Energy Agency, for the Annex I Expert Group on the United Nations Framework Convention on Climate Change (UNFCCC). The goal of the project was to assess a range of cost-effective greenhouse gas mitigation policies and measures for countries and Parties listed in Annex I to the UNFCCC. The working papers served as analytical input to negotiations under the UNFCCC. The working papers may also be useful to national policy makers. The measures analysed do not necessarily represent policy preferences of Annex I Parties.

The project benefited greatly from substantial input from delegates. Three successive chairmen of the Annex I Expert Group provided outstanding leadership for the project: Doug Russell (Canada); Ross Glasgow (Canada); and Ian Pickard (United Kingdom). The work was supervised by Jan Corfee Morlot (OECD). Fiona Mullins (OECD) drafted the initial framework which was used to structure the eighteen working papers.

The Annex I Parties or countries referred to in this document refer to those listed in Annex I to the UNFCCC: Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Czechoslovakia (now Czech Republic and Slovakia), Denmark, the European Community, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Lithuania, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and United States. Where this document refers to "countries" or "governments" it is also intended to include "regional economic organisations," if appropriate.

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## EXECUTIVE SUMMARY

### Aim

This study aims to develop a better understanding of how international greenhouse gas (greenhouse gas) emission trading could help to meet future commitments under the UNFCCC, and to facilitate the development of options for workable emission trading systems. The focus of the study is on emission trading among Annex I Parties to the UNFCCC. The study draws on experience with existing tradeable rights systems (e.g. $SO_2$ allowances, fish quotas, water rights), a review of the literature, and experience from other international agreements. This study does not assess the feasibility of international greenhouse gas emission trading, but rather discusses issues and raises questions about design parameters that would be important for any international emission trading system or framework agreement on emission trading.

### What is emission trading?

Under an international greenhouse gas emission trading system, country emissions would be limited according to their emission targets or "QELROs" commitments.[1] Parties who were subject to such binding emission commitments would be required to hold "greenhouse gas units" equivalent to the amount of greenhouse gases they emitted in order to prove that they had not exceeded their entitled quantity of emissions. Parties could also allocate individual emission limits to emission sources within their jurisdiction such as industries, which would make it possible for individual sectors or firms to participate in the international trading system. Participants would be able to buy and sell greenhouse gas units from each other. If a participant had more greenhouse gas units than it needed to cover its greenhouse gas emissions it could sell the extra greenhouse gas units to another participant who needed them to cover emissions above its entitled level.

### Why trade?

Efficiency gains (i.e. cost reductions), and implementation flexibility, can be achieved through international greenhouse gas emission trading because of differences in the cost of mitigating greenhouse gases in different countries. Emission trading can reduce the cost of greenhouse gas mitigation by allowing participants to reduce emissions where (and possibly when) it is least expensive to do so. There is scope for cost-effective savings in all countries, but model results show that differences in mitigation cost range widely between countries. Lowering the cost of greenhouse gas mitigation can make more stringent environmental objectives achievable. The global warming effects are not influenced by the

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[1] QELROs: Quantified Emission Limitation and Reduction Objectives, i.e. targets and timetables for greenhouse gas emissions (ref: Berlin Mandate.)

location of greenhouse gas emission reductions. Because of this, greenhouse gases are well suited to international emissions trading.

## Definitions

Clear definition of the terms that are needed to discuss emission trading is essential to avoid confusion. In this study, the term *"participant"* is used to refer to any entity that has a binding obligation or agreement to limit greenhouse gas emissions, or enhance sinks, and is either authorised to trade, or chooses to participate in the trading system. Examples of participants are: UNFCCC Parties; sectors or industries; or individual firms. The term *"greenhouse gas unit"* is the generic term used to denote the tradeable unit representing a certain amount of greenhouse gas emissions e.g. 1000 tons $CO_2$ equivalent.[2] An "*emission limit*" is a limit on greenhouse gas emissions.[3]

Features identified in the study as desirable in an international greenhouse gas emissions trading system include: environmental benefits; cost minimisation (facilitated by wide participation and coverage of greenhouse gases); clear rules for changing the overall emission limit and the entry of new participants; equity; ease of implementation; adequate monitoring, verification and reporting (to help ensure confidence in the market); and political feasibility. Inevitably, there will be trade-offs between these features; for example, a system that includes a wide range of participants and greenhouse gas would capture a broader range of greenhouse gas mitigation options but would be more difficult to monitor.

## Design Parameters

1. Emission Limit

Placing binding emission limits on participants will create incentives for emission trading. However, if all participants were allocated weak limits (so that the allowable level of emissions were equal to or above business as usual), or if compliance mechanisms were weak, there would be few incentives to trade. The less strict the limits, the lower the value of the greenhouse gas units would be. Allocation issues, including those related to fairness and redistribution of wealth, are often considered to be the most controversial part of an emission trading system. However, allocation issues are not unique to trading and are not examined in depth in this study. Negotiated emission targets or "QELROs" would provide the basis for determining the individual emission limits needed for an international greenhouse gas emission trading system.

An international trading system would have to be designed from the outset to be flexible so as to allow changes that might be required to the emission limit, for example because of new knowledge on climate change impacts, inclusion of additional greenhouse gas sources and/or sinks, or new participants. An

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2 The term greenhouse gas unit is intended to be broad enough to cover concepts in existing systems and the literature such as "allowances", "credits", "quotas", "tradeable permits" etc.

3 An emission limit could be: a "cap" which is a specified limit on emissions for a specified time period for each participant in the trading system; or a "baseline" from which emission reductions, (or increases) are measured. Examples include: cumulative emission budgets (emissions over a multi-year period); emission reductions from an historical base-year; greenhouse gas intensity per unit of Gross Domestic Product (GDP); or baseline scenarios.

international emission trading system may have to accommodate different domestic trading systems (e.g. allowances or credits systems). To provide flexibility, emission limits for individual participants could be issued periodically in line with UNFCCC commitments. Alternatively, participants could each take a percentage share of any overall emission limit and thus of any future reduction (or increase) required. To minimise uncertainty for participants, the intended adjustment path would ideally be signalled when the emission limit is initially decided. Clear rules should be established from the outset for addition of new participants to the trading system.

Allowing early greenhouse gas reductions to be "banked" for future use would provide flexibility for participants to go further than their required emission limit in early years if it is cost-effective for them to do so, and to save these extra emission reductions to offset future increases in emissions. This would lower the cost of greenhouse gas reductions while contributing to the same environmental outcome reflected in the emission limit. Allowing greenhouse gas units to be "borrowed" from the future to meet current emission limits would also increase flexibility and could lower the economic cost of greenhouse gas reductions. Borrowing would allow participants to mitigate greenhouse gas emissions at lower cost, if mitigation costs turn out to be lower in future periods, for example if less carbon-intensive technologies develop that reduce abatement costs. However, borrowing raises a number of problematic issues, such as possible 'bankruptcy' of participants who find themselves unable to meet future commitments; and reduced market liquidity if all participants were to borrow against their own future emissions allocations rather than trade. Possible solutions to these issues include: requiring greater future reductions to offset the "borrowed" greenhouse gas units; and limiting the amount of greenhouse gas units that can be borrowed. Both banking and borrowing are concepts that could apply to Parties' commitments under the UNFCCC regardless of whether emission trading were to be introduced.

2. Greenhouse gas units

The unit of trade needs to be a clearly-specified type and amount of emissions for a specified period to ensure that participants' rights and obligations are well understood and monitored. Units of trade should be standardised, so that the units are fully exchangeable. However, in order to facilitate accounting of emissions and determine compliance, it may be necessary to identify the country of origin for greenhouse gas units, which might reduce the homogeneity of greenhouse gas units. If all greenhouse gas sources and sinks were included in a trading system, participants would be encouraged to invest in the most cost-effective greenhouse gas mitigation reductions wherever they occurred, thus minimising the aggregate cost of mitigation.

It might be possible to allow all greenhouse gas sources and sinks that can be adequately verified and monitored to be included in a trading system. Participants with sophisticated inventory methodologies could use a comprehensive approach, while other participants might be limited to trading only $CO_2$ emissions due to difficulties in estimating and monitoring emissions. Another alternative could be to establish separate trading regimes for individual greenhouse gases (with effective monitoring and reporting for each system) to minimise monitoring concerns. On this basis, a trading system could begin with $CO_2$ emissions from fossil fuel combustion, which are the easiest to estimate and verify ($CO_2$ from energy is also the single largest contributor to global warming). The trading system could be designed to allow addition of other gases/sources in the future on a global warming potential (GWP) basis as monitoring and verification capacities improve.

3. Possible participants

There would be a larger potential for greenhouse gas mitigation cost savings with wide participation of countries. However, initially it may be more realistic to include only countries with quantified emission commitments in an emissions trading system, while leaving the system open to participation by all countries. To encourage wide participation, the trading system should be kept simple. Using a comparable emissions inventory methodology for all countries would facilitate the eventual involvement of a large number of Parties. Compliance requirements will affect the extent to which different Parties could participate in a trading system. Participation by countries that do not adopt an emission limit could reduce the value of greenhouse gas units and raise the risk that overall greenhouse gas emissions reductions will not be achieved.

Many trade pathways between different types of market participant are possible (see diagram on p. 23). The desirability of including each pathway, or leaving the option open for future inclusion of a pathway, needs to be weighed against the feasibility of doing so. Bilateral trades could be arranged between two governments either through direct negotiations or through intermediaries such as brokers. Such trades would require governments to obtain information on opportunities for and costs of greenhouse gas mitigation. Obtaining this type of information may be difficult. Allowing the participation of domestic entities may reduce the need for governments to gather such information, although it could increase the complexity of monitoring and verification requirements.

International trading could be possible between industries, sectors, or individual firms if their governments implemented domestic emission trading, or allocated emission limits to individual sources. For firms to participate in emission trading, appropriate domestic regulatory, monitoring, and implementation arrangements would be necessary. Trade between individual firms would provide strong incentives for them to exploit any cost-effective greenhouse gas reduction options that were available to them. Firms could either make money by selling "spare" greenhouse gas units, or simply comply with their limits at least cost. Since Parties (not firms) are bound by international agreements, trades between companies in different countries would have to be accounted for at the national level and be consistent with national emission limits derived from emission targets under the UNFCCC.

It may not be feasible to include very small emission sources in a domestic trading system because of the complexity of setting emission limits and monitoring emissions. Governments may instead choose to implement other policies and measures for car drivers, small businesses, and households, such as carbon/energy taxes, energy efficiency standards, or voluntary agreements. Domestic policies and measures will vary between countries due to differences in domestic regulatory structures, the political feasibility of different measures, and the costs of particular control options. The design of a trading system should ideally be compatible with existing domestic regulations and policies such as domestic emission fees, regulations, or different domestic emission trading systems.

"Leakage" of greenhouse gas emissions (i.e. reductions in one region resulting in an increase in emissions in another region) could occur if some countries are required to reduce greenhouse gas emissions and others are not. This is a feature of a limit that does not apply to all Parties. Emission trading could reduce emission leakage by reducing the cost of greenhouse gas mitigation which would lower the incentive for greenhouse gas emitters to re-locate.

4. Monitoring and enforcement

Monitoring mechanisms will be necessary to ensure compliance with UNFCCC commitments. The ability to trade emissions units internationally will also strongly depend on participants being able to account for their emissions and greenhouse gas units at the national level. National monitoring mechanisms could be accredited by the international community and charged with accounting for national emissions and national emission trades. International law does not currently provide a strong legal basis for international monitoring and enforcement. Thus, new mechanisms may be needed to ensure emissions and trades in greenhouse gas units are monitored, and to maintain the credibility of the trading system:

- an international emission accounting function to compile and check information on national greenhouse gas emissions and the sales and purchases of greenhouse gas units between countries;

- standard reporting formats (national inventories based on the IPCC guidelines are already required and could be used as a basis for estimating and reporting greenhouse gas emissions under a trading system); and

- a review/audit function to periodically check each country’s emission accounts.

Given the financial value of greenhouse gas units, the importance of accurately estimating and verifying greenhouse gas emissions would be much higher under an emission trading system than at present. Different levels of enforcement are possible, depending on the desired stringency of enforcement and the cost of enforcement that participants are willing to bear. Parties could agree to impose fines or penalties for excess emissions, tighten future emission limits, prevent non-compliers from participating in international trading, or use the UNFCCC multi-lateral consultative mechanism to resolve disputes on a case-by-case basis.

5. Market mechanisms:

A number of existing market mechanisms such as stock exchanges, information services, and payment mechanisms, could be used for greenhouse gas emission trading. Others may need to be set up, or could develop, in response to market needs. As in other commodity markets, the types of market mechanisms might include:

- brokers (“middlemen” who match buyers and sellers) could help participants make bilateral trades or to trade on an exchange;

- information services (such as bulletin boards quoting prices and quantities of greenhouse gas units sold) which would assist the market to function smoothly by facilitating price convergence and providing greater certainty over the value of greenhouse gas units;

- organised exchanges could match willing buyers and sellers, improve market liquidity, provide information on prices;

- standard documentation such as greenhouse gas unit transfer forms, confirmation notices and other accounting documents would facilitate trading;

- accreditation bodies (for example, to certify national monitoring institutions and exchanges).

The greater the administrative or other effort required for making trades, the higher the costs participants will face for trading greenhouse gas units. If each project must be examined and approved before greenhouse gas units can be traded, the system could have higher on-going administrative costs. To reduce transaction costs the role of governments in any national trading systems should be kept to the minimum necessary to ensure compliance with their international commitments under the UNFCCC (e.g. monitoring and reporting national emissions). These functions would help ensure confidence in an international greenhouse gas emission trading system.

Large holders of greenhouse gas units could have incentives to hoard greenhouse gas units to increase the value of their units. The threat of market power would be lower in a market with a large number of diverse participants, in which the greenhouse gas units can be easily traded. A strategic reserve or "buffer" of greenhouse gas units held by an international entity (perhaps auctioned periodically) would reduce the ability of large participants to prevent new entrants from purchasing greenhouse gas units or from hoarding greenhouse gas units to drive the price up.

***Possible barriers***

Establishing an international emission trading system would not be simple. Possible impediments include: lack of experience with international emission trading systems; lack of confidence in countries' monitoring systems; or industry opposition to government control of and involvement in the trading process. There could also be a concern that participating countries, in purchasing greenhouse gas units from other countries, may neglect to implement (or make progress towards implementing) politically difficult measures at home. To reduce this concern, the percentage of a country's national commitment that could be met through trading could be limited, although this could have adverse effects on the efficiency of the market, reduce the number of trades, and would represent a compromise of countries' flexibility to mitigate greenhouse gas emissions.

**Conclusions**

Discussion of international greenhouse gas emission trading is still at a preliminary stage. greenhouse gases are well-suited to international trading because the location of greenhouse gas emission reductions does not affect global warming. International greenhouse gas emission trading among countries with emission limits (such as QELROs under the UNFCCC) would increase flexibility over where (and possibly when) greenhouse gas mitigation can take place, and so reduce the cost of greenhouse gas mitigation.

Difficulties in monitoring, reporting, and verification might make it impractical to implement an emission trading system covering from the outset all greenhouse gases, all sources and sinks, and all Parties. During the delay that such difficulties would cause, opportunities to trade would be lost. An international emission trading market would be more likely to start with a limited number of participants and greenhouse gases that can be adequately monitored. The market could then evolve to become more fully comprehensive and more cost-effective. Existing national market and monitoring institutions could be used to gain experience on trading, while considering the need for any additional international institutions for a longer term, more comprehensive system. Some countries with limited capacity to set up monitoring institutions needed for trading might first begin trading greenhouse gas units earned from projects that have emission baseline limits and adequate monitoring.

Further work is needed on the issues discussed in this study to improve understanding of emission trading and to share ideas on key design issues if workable options for international emission trading are to be developed.

## INTRODUCTION

### Aim

This study aims to develop a better understanding of how international greenhouse gas emission trading could help to meet future commitments under the United Nations Framework Convention on Climate Change (UNFCCC), and to facilitate the development of options for workable emission trading systems. The focus of the study is on emission trading among Annex I Parties to the UNFCCC.

The study draws on experience with existing tradeable rights systems (reviewed in Appendix 1), a review of the literature, and experience from other international agreements. Practical experience with international emission trading is still very limited. Consequently the study does not assess the feasibility of international greenhouse gas emission trading. Instead the study discusses issues and raises questions about design parameters, including implementation and operational issues, that would be important for any international emission trading system or framework agreement on emission trading.

### What is emission trading?

In a tradeable "permits" system, an environmental goal is set and polluters are required to hold a certificate or permit for each unit of pollution they emit (in some systems, such as the "baseline and credits" system described in Appendix 1, polluters must hold a certificate only for the units of pollution they wish to sell). If a participant has permits it does not use, it can sell them to another participant who needs extra permits to cover excess pollution (above its limit). Thus, such systems reward over-achievement by providing financial compensation for reduction of pollution below required levels. Through such trading, a market price for the permits emerges which reflects the cost of pollution reduction.[4] Each participant can then decide whether it is cheaper to reduce pollution or to purchase permits.

Under an international greenhouse gas emission trading system, country emissions would be limited according to their emission targets or "QELROs" commitments.[5] Parties who were subject to such binding emission commitments would hold "greenhouse gas units" (see definitions below) equivalent to the amount of greenhouse gases they emitted. Under an international greenhouse gas emission trading system, countries would retain full flexibility over what greenhouse gas mitigation measures they take domestically. Parties could allocate emission limits to individual emission sources such as industries,

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[4] In theory, tradeable permits have the same economic-efficiency properties as taxes, and should have an equivalent effect on pollution. In tradeable permits systems, a restriction is placed on the quantity of pollution that is allowed which results in a price emerging for the restricted commodity. In tax systems, a price is charged for the pollution, which results in a reduction in the quantity of pollution "demanded".

[5] QELROs: Quantified Emission Limitation and Reduction Objectives ("The Berlin Mandate": UNFCCC Decision 1/CP.1; FCCC/CP/1995/7/Add.1).

which would make it possible for individual sectors or firms to participate in the international trading system.

Emission trading can reduce the cost of greenhouse gas mitigation by allowing participants to reduce emissions where (and possibly when) it is least expensive to do so. Through international emission trading, emissions reductions (or sink enhancements) can be made at lower cost by enabling measures to be taken wherever the most cost-effective solutions are found. If a trading system also allowed participants to save emissions reductions (or sink enhancement) for use in a future period or borrow emissions from future periods, they would have additional flexibility to achieve reductions *when* it were most cost-effective to do so.

There is scope for cost-effective greenhouse gas mitigation in all countries, but model results show that differences in mitigation costs vary widely. Efficiency gains (i.e. cost reductions) can be achieved through international greenhouse gas emission trading because of differences in the cost of mitigating greenhouse gases among countries.[6] Estimates of the marginal cost of greenhouse gas mitigation in different countries, and of the economic gains that could be achieved through international emission trading, are provided in Appendix 2.

Emission trading among some or all Annex I parties may be particularly relevant once targets and timetables for greenhouse gas emission limitation and reduction are negotiated under the "Berlin Mandate". The types of decisions that might be needed from the UNFCCC Conference of Parties to facilitate international greenhouse gas emission trading include:

- a binding emission reduction obligation for each Party that wished to participate in the emission trading system; and
- a change to the current reporting obligations to account for greenhouse gas units bought and sold.

Efficiency, cost and flexibility considerations are critical in determining how far countries can reduce their net greenhouse gas emissions. International emission trading provides an incentive for countries to go further than their negotiated emission targets, because they can be financially compensated by selling the greenhouse gas units that represent the extra emissions reductions. By lowering the cost of greenhouse gas mitigation emission trading could make more stringent environmental objectives achievable.

Even among a small group of countries, or Annex I countries only, emissions trading would lead to lower cost greenhouse gas mitigation for those countries. There could also be advantages from non-Annex I Parties joining an emission trading system, should they choose to do so, both from: increased finance for greenhouse gas mitigation in developing countries which could enhance technology transfer, aid development, local pollution reduction; and from lower cost global greenhouse gas emission reductions.

The global nature of climate change, and the fact that the location of emission reductions will not alter their global environmental effect, make greenhouse gases well suited to international emissions trading. In contrast, emission trading systems that aim to address local or regional air quality problems may require constraints on trading, for example to prevent concentrations of unacceptably high emissions in any area.

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6 A fully operational trading regime would help determine the marginal cost of reduction among participants.

**Developing a common language**

Analysts often use different terms for similar concepts to discuss trading. Some terms derive from experience, drawing on trading systems that have been implemented in a number of countries, such as: air emissions trading in the United States; tradeable fishing rights in New Zealand, Canada, Australia, Iceland, Great Britain; tradeable water rights in various countries; and trading in CFCs under the Montreal Protocol. Each system has its own jargon that may not be easily understood by a wider audience. To avoid confusion, the main terms that are used in the study are defined below. These may differ from those used for existing trading systems.

"**Participant**": In this study, the term participant is used to refer to any entity that: (i) has a binding obligation or agreement to limit greenhouse gas emissions or enhance sinks to remain within their allowed level of emissions, and (ii) are authorised to, or choose to, participate in trading. Participants discussed in the literature range from:

- a UNFCCC Party or country;
- a sector or industry (e.g. fossil fuel producers or importers, electric utilities);
- individual firms.

The term participant is used when discussing issues that are relevant for any of these types of participant. For issues that are relevant only to governments, UNFCCC Parties, or countries, and not to other types of participant, the term "participating country" is used.

"**Greenhouse gas unit**": The term "greenhouse gas unit" is used to denote the tradeable unit representing a certain amount of greenhouse gas emissions e.g. 1 000 tons $CO_2$ equivalent. "Greenhouse gas unit" is a generic term chosen to avoid using a term that has specific meaning and associations in existing trading systems or literature. However, when existing trading systems are discussed in the study, the specific term used for the tradeable unit of each system is referred to e.g. "permit", "allowance", "credit", or "quota".

"**Emission limit**"[7]: A limit on greenhouse gas emissions for specified time periods for each participant is needed for there to be incentives to trade. Participants would only be allowed to exceed their emission limit if they purchased greenhouse gas units that represented emission mitigation by other participants. Emission limits could be based on:

- a pre-existing (historical) emission level (e.g. 1990 greenhouse gas levels, or percentage thereof);
- a projection of future emission levels;
- a cumulative emission target spanning several years;
- average annual emissions over the period;
- policies and measures which participants are required to meet, such as performance standards per unit of output;
- emissions per capita or per unit of Gross Domestic Product (GDP).

Any reductions below the emission limit (the difference between the emissions allowed by the limit and actual emissions) can be traded.

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[7] Another term for an emission limit that is often referred to is an "emission budget".

**Features of successful trading systems**

It is important to identify the features that would ideally be present in an international greenhouse gas emission trading system to provide objective criteria which could be used to assess different trading systems. The following list of features is provided as a starting point. Because experience with international emission trading is still limited, it will be necessary to amend this list as understanding of international emission trading develops. Features that might characterise a successful international greenhouse gas emission trading system include:

- Environmental benefits. Participants and non-participants will be concerned to ensure that the environmental obligations of all countries and firms are being met. The trading system must not be seen as a mechanism for avoiding such obligations. In fact, binding emission limits that reduce greenhouse gas emissions from the group of participating countries are a necessary prerequisite for setting up an emissions trading system.

- Cost minimisation. An important feature of trading systems is that they allow greenhouse gas mitigation to be carried out where the least cost potential is found within the group of participating countries. Participation in the trading system by countries with a variety of mitigation costs would enhance cost minimisation potential. A wide coverage of greenhouse gases would also increase the potential pool of low-cost greenhouse gas mitigation opportunities. A trading system would ideally have very low implementation, transaction, and administration costs.

- Confidence in the trading system. Strong monitoring is needed to ensure confidence in the trading system (see monitoring section below), including accurate accounting of national greenhouse gas emissions and of trades in greenhouse gas units between participants. Strong penalties for participants that are not in compliance with their emission limits would increase confidence in the market. A competitive market with many participants and a credible price signal emerging early would also help provide participants with certainty.

- Clear rules for changes to the trading system. Ideally a trading system would remain flexible enough to enable new participants to join, or to broaden the system to include additional greenhouse gases, or to change the emission limit. However, to give participants certainty, clear rules would be needed for making such changes to the trading system.

- Equity. A trading system will ideally be perceived by all participants to be equitable, based on well accepted equity criteria such as the "polluter pays principle". The main equity concerns will depend on the QELROs that are negotiated in the UNFCCC context, which would form the basis for national emission limits.

- Political feasibility and ease of implementation. An international emission trading system would ideally be able to work together effectively (and in synergy) with domestic trading systems, other policies and measures, and existing domestic institutions, in order to reduce the costs of implementation and enhance political acceptability for all participating countries and industries.

There will inevitably be trade-offs between these features. For example, trades under a system that includes a wide range of participants and greenhouse gas would capture a broad range of greenhouse gas mitigation options but confidence in the market may be low due to the difficulty of monitoring some participants and greenhouse gases. Similarly, a low-cost international greenhouse gas emission trading system might not be possible if a high degree of market certainty, requiring expensive monitoring systems, were desired.

## DESIGN PARAMETERS

### Emission Limit

Placing binding limits on participants will create incentives for emission trading. If a weak limit were chosen, so that the allowable level of emissions were equal to or above "business-as-usual", there would be few incentives to trade.[8] The less stringent the limit, the lower the value of the greenhouse gas units would be. If transaction costs per greenhouse gas unit outweighed the lower cost of greenhouse gas reduction by other participants, there would be no profit to be made from trading.

### *Allocation*

In addition to an overall limit on emissions, an emissions limit would be needed for each participant (i.e. each participating country or individual source) for specific time periods. These individual emission limits are likely to be achieved through allocation (or negotiation) of an emission limit for each participant. Allocation issues, including those related to fairness and redistribution of wealth, are often considered to be the most controversial part of an emission trading system. The effects of some basic allocation rules on emission limits for Annex I Parties are illustrated in Appendix 3 of this paper. However, allocation issues are not unique to trading and are not examined in depth in this study. Governments might wish to allow individual emission sources to trade greenhouse gas units through allocating emission limits to individual emission sources within their jurisdiction.

Negotiated emission targets or "QELROs" would provide the basis for determining the individual emission limits for Parties in an international greenhouse gas emission trading system. However, there are a few types of target that may not translate directly into the national emission limits needed for an emissions trading system. For example:

- if one or several Annex I regional emission target/s were negotiated, but individual Annex I countries did not adopt individual targets;

- if national caps were negotiated for a time period far in the future, or if cumulative emission budgets that cover a long period were agreed, shorter term allocations or interim targets and reporting might be needed to encourage more and earlier trading; or

- if the negotiated targets covered all known greenhouse gases but only some greenhouse gases, or some greenhouse gas sources and sinks, could feasibly be included in a trading system initially (see "what is traded" section below).

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8 "Business-as-usual" is the name commonly given to scenarios for future emissions paths that assume no measures are taken to limit emissions.

### *Changes in the emission limit*

Emission limits that span a long period, or do not change frequently, provide a higher degree of certainty for participants. Certainty over a longer time horizon would enable participants such as industries to plan capital investment to achieve their future emission commitments. However, emission limits that are fixed over a very long period might commit future governments to a course of action that could be more than required or too little to avoid adverse consequences. Because of this, an international trading system would have to be designed from the outset to be flexible enough to facilitate any changes that might be required to the overall emission limit.

Future UNFCCC negotiations could lead to agreement on changes to the emission targets and timetables on which participating countries' emission limits would be based. UNFCCC Parties may decide to make emission targets more or less stringent, which, in turn, would require changes to the emission limits of participating countries' and firms. Examples of issues that could require changes to the emission limit are:

- changes in the cost of measures to mitigate climate change, or better understanding of climate change impacts which would shed light on the appropriate level of effort to limit or reduce greenhouse gas emissions;

- changes to the greenhouse gas sources and/or sinks included in the trading system;

- changes to Global Warming Potentials (GWP) in response to better information;

Since participants need certainty, it is important for the intended adjustment path to be signalled when the emission limit is initially decided, and changes to the emission limit would have to be scheduled well in advance. Factors that may lead to changes in the level of emissions reductions required should be identified to the extent possible. Institutional arrangements for such changes should be built into the design of the trading system.[9] Changes to emission limits would ideally be infrequent to minimise uncertainty.

Various design features could help provide flexibility for the emission limit to change:

- emission limits for individual participants could be issued periodically (this would provide flexibility but would also increase uncertainty);

- all participants could agree to take a percentage share of any overall emission limit and thus of any future reduction (or increase) required;[10]

- Greenhouse gas units could be issued on an ongoing basis, with some future years' units allocated in each current year;[11]

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9 New Zealand Ministry of Environment, 1996 p.103

10 An example of this is tradeable fishing quotas, OECD 1992 p. 120

11 Bertram, 1992. For instance, in each current year, each participating country could be issued a certain percentage of allowances for future years, to provide certainty for a percentage of the future emission limit but allow for the possibility of a future reduction in the total emission limit. The remaining percentage (or less) would be issued closer to the relevant period.

– the amount of greenhouse gas emissions covered by each greenhouse gas unit could be changed (e.g. greenhouse gas units initially worth 100 t $CO_2$ equivalent could be worth only 80 t $CO_2$ equivalent); or

– participating governments could buy and permanently retire greenhouse gas units from the market to lower the overall emission level allowed in the trading regime, perhaps according to agreement among all participating countries.

*Banking*

Participants may be allowed to “bank” greenhouse gas units, i.e. save them for future use or to sell to other participants in the future.[12] If banking is allowed, greenhouse gas units could be used either to offset emissions in the year the units were issued or, if they were not used, the units could remain valid to offset emissions in future years. Banking could be a feature of any emission limitation commitment, regardless of whether an emission trading system were established.

Banking would not adversely affect the environment. Increased emissions in future that are above the agreed emission limits will have been offset by earlier reductions. Cumulative emissions and greenhouse gas concentrations thus will not be adversely affected. Banking would provide certainty that unused greenhouse gas units could be used to offset future emissions or to sell to others. Participants could therefore be more willing to go further than their required emission limit in early years if it were cost-effective for them to do so. Banking could add to the liquidity of the market for greenhouse gas units by creating a larger pool of greenhouse gas units that could be traded, which would re-assure participants that greenhouse gas units would be available in the future. Thus banking could improve market confidence, increase liquidity, and smooth price fluctuations. However, if participants with large amounts of unused greenhouse gas units banked these for long periods, other participants would be prevented from purchasing them, which could lead to fewer trades (i.e. lower market liquidity).

*Borrowing*

“Borrowing” is another way to increase flexibility and lower the economic cost of greenhouse gas reductions.[13] Borrowing allows future allocations of greenhouse gas units to be used to offset greenhouse gas emissions in excess of the emission limit in the current period. As with banking, borrowing could be a feature of any emission limitation commitment, regardless of whether an emission trading system were established. Borrowing could allow participants to mitigate greenhouse gas emissions at lower cost if mitigation costs were lower in future periods. For example low cost carbon-free or less carbon-intensive technologies may develop in the future that would reduce the cost of greenhouse gas mitigation.

However, borrowing raises a number of problematic issues. If participants were to use or sell large amounts of future greenhouse gas units and could not cover these through future greenhouse gas mitigation or by purchasing from others, they could face the equivalent of ‘bankruptcy’ in not being able to meet their commitments. Borrowing would also make it more difficult to check that participants are in compliance or *en route* to meet their emission limit unless borrowing is only allowed over a short period of time (say, from the next year only). If all participants were to borrow from their future emissions

[12] The long-term duration of greenhouse gas units (and the ability to bank surplus units) is a feature in the $SO_2$ allowances programme in the US.

[13] Richels *et al*, 1996

allocations rather than trade, market liquidity could suffer making it more difficult to achieve a fully operating international market for greenhouse gas units.

A number of safeguards might be developed to allow borrowing without under-mining the environmental objectives. Participants could agree how far in advance greenhouse gas units could be "borrowed" for compliance (e.g. 1, 5, or 10 years). Periodic check-points could be set at which each participant's situation would be assessed with respect to its cumulative emission limit. Borrowed units could incur a penalty, with more reductions being required in the future to offset any borrowed greenhouse gas units. Participants could agree to prohibit the use of borrowing if emission trajectories make it unlikely that additional reductions can be achieved in the future. The extent of reliance on borrowing could be limited e.g. to a certain percentage of the emission limit. The use of borrowed greenhouse gas units for sale to others could also be prohibited. With such safeguards, borrowing could potentially provide added flexibility to achieve greenhouse gas mitigation objectives cost-effectively.

*Strategic reserve*

Another option to increase market confidence, and to provide certainty that environmental objectives will be met, could be to establish a "strategic reserve" or pool of emissions to be held in reserve to ensure that emissions do not exceed the overall limit.[14] Participating countries could allocate a proportion of their greenhouse gas units to the reserve to act as a "buffer" of greenhouse gas units in case any participants over-shoot their emission limit (these reserve greenhouse gas units would still belong to the participants but could not be used until the second or later year).

A strategic reserve would reduce the likelihood of countries not meeting their commitments and so would enhance certainty in the market over the value of the greenhouse gas units. A pool of greenhouse gas units held by an international entity could also reassure all participants (whether countries, or individual firms) that they would be able to purchase greenhouse gas units in the future and so facilitate more and earlier trading.[15] A reserve of greenhouse gas units could also reduce the threat of market power if greenhouse gas units from the reserve were auctioned each year, or sold at a set price.[16]

## What is traded?

### *Unit of Trade*

The unit of trade needs to be clearly defined (a specified type and amount of emissions for a specified period) so that participants' rights and obligations are well understood and can be adequately monitored. greenhouse gas units would ideally be standardised so that they are fully exchangeable. However, in order to facilitate accounting of emissions for determining compliance, it may be necessary to identify the country of origin on the greenhouse gas units.

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[14] Bohi, Burtraw et al 1990, UNCTAD 1996

[15] In the US $SO_2$ program, independent power producers planning to construct new power plants expressed fears that allowances would not be available to them in sufficient supplies to offset their new emissions even at the $1500 per ton level. As a result a special Administrator's Reserve was created for administrative purposes at $1500 a ton.

[16] UNCTAD 1996 p. 34

A weighting index such as Global Warming Potentials (GWPs) could be used to translate greenhouse gases into $CO_2$ equivalent units for trading.[17] GWP values would need to be agreed at the outset for evaluating greenhouse gas units for gases other than $CO_2$, including the time horizon to be used. GWP values could be set based on the best scientific knowledge at the time.[18] Due to uncertainties over some GWPs, the GWP values adopted for the trading system might be the subject of negotiation, and would need to change periodically as scientific knowledge improves. Confidence intervals for estimations of different greenhouse gases might also need to be agreed by participating countries. Because there is a clear and constant relationship between fossil fuel inputs and $CO_2$ emissions, greenhouse gas units for $CO_2$ could be based on quantities of fossil fuel consumed rather than emissions. The nitrogen content of fertilisers might similarly be used as a proxy for $N_2O$ emissions.

The period for which an "unused" greenhouse gas unit remained valid would have to be considered in designing an emission trading system. greenhouse gas units would be valid for the year (or period) for which they were issued. If banking were allowed, any greenhouse gas units that were "unused" (i.e. not needed to cover emissions in the period they were issued) could remain valid for future periods as well. Alternatively, the emission limits and equivalent greenhouse gas units could be valid "in perpetuity" rather than being limited to a single "use", so that the greenhouse gas units would remain valid to cover a specified amount of emissions each year.

***Comprehensiveness: which greenhouse gases are traded***

The confidence participants have in methodologies for estimating and monitoring greenhouse gas emissions and removal by sinks will influence which greenhouse gases can be included in a trading system. A comprehensive trading system would be more difficult to monitor and could have higher transaction costs than, for example, a trading system including only $CO_2$ from fossil fuel combustion. It might be difficult to define which gases, sources and sinks to include in a trading system because of differences between countries in levels of sophistication of measuring emissions, costs of mitigation for different sources and sinks. Proportions of greenhouse gases will also differ among countries, which will affect countries' preferences for which greenhouse gases to include in an emission trading system.

Including all greenhouse gas sources and sinks in an emission trading system would have significant advantages. A trading regime including all greenhouse gases would provide incentives for least-cost greenhouse gas mitigation options to be sought across all greenhouse gases. Wide coverage of greenhouse gases would also enable participants to address non-$CO_2$ emissions which in some countries are very large sources of greenhouse gas emissions. Less broad coverage of greenhouse gases would risk distorting mitigation towards those sources and sinks that were included in the trading system and away from potentially cost-effective mitigation options for other sources and sinks.

It might be possible to allow any greenhouse gas sources and sinks that can be adequately verified and monitored to be included in the trading system. Under legally binding emission limits, Annex I Parties

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[17] The relative cumulative radiative forcing effect of different gases varies according to the timeframe over which they are measured. IPCC SAR, WG I, p. 121

[18] At present global warming potentials (GWPs) are uncertain for a number of gases due to the complexity of chemical interactions among gases, and the direct and indirect effects on radiative forcing. The uncertainty levels over direct and indirect radiative forcing potential is higher for some gases than others, and different gases are active in the atmosphere for different timeframes so it is not obvious which timeframe should be used to calculate GWPs - 20 year, 100 year, 500 year.

would be liable for all greenhouse gas emissions covered by these limits. If countries or participants with sophisticated inventory methodologies could document reductions from their emission limits adequately for a range of different greenhouse gases, it may be possible for them to trade the greenhouse gas units representing those reductions. The greenhouse gases a participant wished to trade would have to be announced and agreed by other participants well in advance so that the pool of emissions available for trading were known. Other participants with less sophisticated monitoring might be limited to trading only $CO_2$ emissions, or greenhouse gas emissions from certain sources only, at least in the near term, due to difficulties in estimating and monitoring emissions. This approach of allowing trade of any greenhouse gas units that can be verified would allow more flexibility, and provide incentives for the development of approaches for controlling non-$CO_2$ greenhouse gas and for developing better approaches for quantifying and controlling non-$CO_2$ greenhouse gases.

Initially, the coverage of a greenhouse gas trading system may have to be considerably narrower in scope than the commitments which countries negotiate. A less comprehensive system might be necessary because of the difficulties in estimating and monitoring some greenhouse gas emissions. Inventories of $CO_2$ emissions from fossil fuel combustion have the highest degree of certainty associated with estimates, (and is typically over 95 per cent of $CO_2$ emissions from countries that have reported).[19] $CO_2$ is also by far the most important greenhouse gas, contributing about 64 per cent of the total radiative forcing since pre-industrial times;[20] energy-related $CO_2$ emissions are the dominant greenhouse gas source in Annex I Parties, where fossil fuel represent more than 90 per cent of total energy use.[21] A trading system could begin with $CO_2$ emissions from fossil fuel combustion since these emissions are the most verifiable and easily measured.

For a wider scope of sources and emissions, differences in uncertainty among greenhouse gas emission and removal estimates would have to be addressed.[22] The introduction of less reliable greenhouse gas units may artificially reduce greenhouse gas unit prices, which could discourage greenhouse gas mitigation that would otherwise be taken. It might be possible to use a scaling factor for less certain greenhouse gases to take into account the uncertainties in estimating them. For example, 1 unit of $CO_2$ sequestered in a forestry plantation might be scaled down by an agreed factor (e.g. 50 per cent) to be equivalent to, or traded for, 1 unit of $CO_2$ from fossil fuel. However, this would reduce the value of sequestration relative to fossil fuel emission reduction, and could limit investment in some of the most cost-effective greenhouse gas mitigation measures.

An alternative could be to establish separate trading regimes for individual greenhouse gases which cannot be measured as accurately as energy-related $CO_2$. As the markets in greenhouse gas units develop, and estimation techniques and monitoring improve, it may become more feasible to bring other greenhouse gases into the market for more reliable greenhouse gases. Only when greenhouse gas units cover a wide

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19 FCCC/CP/1996/12/Add.1 p. 20

20 IPCC SAR, WGI p. 109

21 $NO_x$ estimates are typically given a high to medium confidence rating by Annex I countries. Emission co-efficients and emissions data for $NO_x$ are of high quality, but GWP values for $NO_x$ are uncertain due to multiple effects of tropospheric ozone formation, which may make it difficult to define $CO_2$ equivalent $NO_x$ units for trading. In any case $NO_x$ is a much less important gas than $CO_2$ in global warming terms. For $N_2O$ the emission coefficients have large error margins, but the GWP is better known. Estimation of methane emissions might be feasible for sources where methane is captured, such as landfills or coal-bed gas recovery, and natural gas networks, since these emissions are easily estimated and/or monitored.

22 Swart, 1993 p. 46

range of greenhouse gas will participants have full opportunity to obtain minimum cost reductions across a range of activities. However, the markets for some gases may not have enough participants to ensure a competitive market, and the range of cost-effective mitigation options available to participants would be reduced.

Better measurement practices are likely to be developed for all greenhouse gases, sources and sinks, which would make it easier to trade greenhouse gas units across all greenhouse gases (an increase in methane emissions could be traded for an increase in sequestered carbon in forests) on a GWP basis. A trading system should be designed to allow flexibility for possible addition of other greenhouse gases in the future as emission estimation techniques become refined enough for adequate monitoring of emissions.

**Who trades: possible participants**

***Annex I Governments***

Annex I Party commitment(s) under a new protocol or another legal instrument that will be established at the third Conference of the Parties in December 1997, will "elaborate" policies and measures, and set emission targets and timetables ("QELROs").[23] Negotiated emission targets could provide the basis for determining the emission limits for Parties that are necessary for an international greenhouse gas emission trading system.

Trade in greenhouse gas units could take place between Annex I governments. It a country's emissions were below its agreed emission limit, the government might decide to sell greenhouse gas units to another government. The government of any country that exceeded its emission limit could buy greenhouse gas units from another country. For example, a government may have an emission limit of 100 million tonnes of $CO_2$ equivalents (Mt $CO_2$), but may only emit 95 million tonnes. This country so would therefore have greenhouse gas units worth 5 Mt $CO_2$ equivalent available to sell. Another government may expect its emissions to exceed its emission limit by 3 Mt $CO_2$ so would need to purchase the extra greenhouse gas units it needed from another participant in the trading system at a negotiated price. In this way, the overall emission limit (among all participants) would be achieved, while allowing participating countries to implement the most cost-effective set of greenhouse gas mitigation options.

Government trading would require governments to obtain information on opportunities for and costs of greenhouse gas mitigation in their country. Obtaining this type of information may be difficult. Allowing domestic entities such as individual firms to participate in the international emission trading system would reduce the need for governments to gather such information. However, monitoring a large number of industry participants would be more complicated than relying on aggregate fuel consumption figures to estimate national $CO_2$ emissions as some countries do now.

It is possible that not all Annex I Parties with commitments would want to (or would qualify to) engage in trading. If both banking and borrowing were allowed in order to meet negotiated emission targets, some countries might prefer to save any early reductions or borrow from the future rather than incur the transaction costs of trading with other participants. Some Annex I Parties may not have sufficiently good emission inventories to give other participants confidence that their greenhouse gas units would represent

[23] UNFCCC Decision 1/CP.1; FCCC/CP/1995/7/Add.1

real emissions reductions. A country with limited capacity to set up the monitoring institutions needed for trading of greenhouse gas emissions from all sectors, might first begin trading greenhouse gas units earned from projects or sectors that have emission baseline limits and adequate monitoring.

Governments of participating countries could have multiple and perhaps conflicting roles: they would be responsible for negotiating agreements on emission limits, monitoring and reporting domestic emissions and trades, and also could be actively trading greenhouse gas units in the international market. Under any system, there would be an incentive for existing participants to attempt to negotiate an outcome that benefits them. As existing participants would have a vested interest in the outcome (such as wanting a likely seller of greenhouse gas permits to adopt a tough emission limit), negotiations over emission limits for new participants could be difficult. Possible market power issues associated with existing participants attempting to “game” the market in their favour through negotiations with potential new participants would need to be addressed in the design of the trading system.

***Non-government participants***

To allow non-government participants to trade, governments could pass some (or all) of their national greenhouse gas units through to individual emission sources such as industries or companies. A country’s greenhouse gas units could be allocated or auctioned to domestic industries, giving them individual emission limits. If their emissions were lower than their stock of greenhouse gas units, individual companies could sell greenhouse gas units to companies in other countries whose governments had acted similarly.[24] If greenhouse gas units were auctioned, so that companies had to buy their allocation of greenhouse gas units, the effect of allowing companies to trade would be equivalent to making them pay a tax on the carbon content of fuels; each emitter would pay for the $CO_2$ they release into the atmosphere.

The participation of many private sector participants could increase the number of trades, which would improve market liquidity and would reduce the potential for abuse of market power. Private sector companies are likely to be more aware of the cost they would face to mitigate greenhouse gas emissions than governments. Individual companies would have incentives to exploit the cost-effective options for greenhouse gas reductions in their operations. Transaction costs of trading greenhouse gas units might be lower in a system allowing trading among companies that are accustomed to dealing with each other.[25] Industries might also have higher incentives to monitor their own and other’s emissions under an emission trading system, in order to foresee market developments and maximise their gain from trading greenhouse gas units.

However, international trades by private sector participants could be problematic if strong monitoring and enforcement is lacking: "In the absence of adequate regulation and enforcement in both countries international inter-firm trading of greenhouse gas could lead to increased emissions”.[26] There are also advantages to keeping the number of participants in the system to a manageable size in order to minimise demands on monitoring and verification systems.[27]

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[24] Grubb and Sebenius in OECD 1992, p. 189, also Bertram 1992

[25] Nussbaum, in OECD 1992.

[26] OECD 1992 p. 55

[27] OECD 1992 p. 21 and p. 151

Since Parties (not firms) sign international agreements, trades among companies would have to be accounted for at the national level. For a country's individual firms to trade greenhouse gas units internationally, monitoring and reporting emissions from individual firms would have to be required by the government. Monitoring would have to be adequate to assure the international community that national emissions and the greenhouse gas units that are bought or sold were reconciled with the country's international emission commitment. When companies traded greenhouse gas units with companies in other countries, the greenhouse gas units they bought or sold and their allocation of greenhouse gas units would have to be linked to the domestic government's emission limit through a domestic monitoring system. Monitoring requirements would need to be consistent for all participating countries, and would ideally be agreed during the design of the international emission trading system as they would affect all participants.

***Non-Annex I Parties***

The larger the number of countries with different control costs participating in the trading system the greater the potential for greenhouse gas mitigation cost savings would be. However, initially it may be more feasible to include only countries with quantified emission commitments in an emission trading system. The trading system could be designed to allow participation by all countries in the long-term. Even though non-Annex I Parties already have general commitments under the UNFCCC, the protocol or other legal instrument will not commit these Parties to specific greenhouse gas emission targets. As discussed earlier in the paper, an emission limit on each participant is necessary to provide the rationale for real greenhouse gas reductions (or sink enhancement) that can be traded. Participation in a trading system by non Annex I Parties that do not adopt an emission limit could reduce the value of allowances and raise the risk that overall greenhouse gas emissions reductions will not be achieved.

Parties who do not initially adopt an emission limit could opt to participate in an international emission trading system at some point in future by adopting emission limits. For example, non-Annex I Parties might agree to adopt an increasing emission projection as a limit on emissions growth, which would enable them to participate in the trading system while not constraining future development. However, as discussed in the "emission limit" section above, the overall emission limit on all participants (i.e. the total of all individual limits) must require a sufficient reduction effort for the value of greenhouse gas units to outweigh the transaction costs of trading. Other participants may be concerned that the introduction of a country with a weak limit may increase the supply of greenhouse gas units, which would reduce the value of greenhouse gas units held by existing participants.[28] However, the extent and direction of the price effect is difficult to determine given that the entry of new participants would also have an effect on the overall emission limit. Clear rules should be introduced at the outset for the entry of new participants to the trading regime, and should be more fully considered in further work.

The monitoring and compliance requirements of a trading system will also affect the extent to which non-Annex I Parties could participate in a trading system. To encourage wide participation, there would be advantages to making any trading system very simple, based on the most easily tracked activities or greenhouse gases. Using a comparable emissions inventory methodology for all countries would facilitate the future involvement of other Parties.

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28 UNCTAD 1996, p. 48

An alternative to involve Parties who do not adopt national emission limits would be to establish project or sector level emission limits.[29] For this to work, binding limits for the individual projects or sectors would be needed (such as baselines of projected emissions) and adequate emission monitoring would be necessary to provide assurance that emission reductions from the baseline were really occurring. "Project crediting" with an agreed baseline (i.e. an emission limit) and verification of reductions from the baseline could be used to generate greenhouse gas units. A country without a national emission constraint may be able to provide adequate emission estimates for a sector of its economy, and an emission limit over this sector could be agreed in order to allow the individual emission sources in the sector to participate in the international emission trading system. The sector would have to be well defined to minimise the possibility of leakage of emission from the sector with the emission limit to other sectors.

***Possible trade pathways between participants***

There are many possible trade pathways between participants for buying and selling greenhouse gas units, depending on how an international trading system were designed, and the types of participant that wished to, and were authorised to, participate. The diagram above: "Possible International greenhouse gas Emission Trades" shows some possible combinations for buying and selling greenhouse gas units between different types of participant. This diagram is not intended to represent any particular system for international greenhouse gas emissions trading; it is merely an aide to thinking about the different possibilities for emission trades that need to be considered in designing an international emission trading system.

Each possible trade pathway (denoted by arrows) will have implications for the design of a trading system. The desirability of including each trade pathway, or of leaving the option open for future inclusion of a pathway, needs to be weighed against the feasibility of doing so. The diagram includes the full range of different participants that is discussed in the literature: Annex I Parties, non-Annex I Parties, governments, and individual emission sources such as fossil fuel producers, industries, and even individual car drivers or householders.

**Annex I Parties:** Whatever the structure and the nature of the commitments negotiated under the Berlin Mandate (depicted by "Annex I Commitments" in the diagram), it is possible that Annex I Parties' commitments could be achieved, at least in part, through greenhouse gas emission trading. Annex I Parties are denoted in the diagram by solid lines, which denote binding emission limits which, as

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29 The concept of trading greenhouse gas units for individual projects is essentially the same idea as AIJ, if credits were allowed. At times the terms Activities Implemented Jointly (AIJ), Joint Implementation (JI), and emission trading are used inter-changeably. In our view, they are related but different concepts:

- AIJ is in a pilot phase during which no credits are allowed while experience is gained on defining baselines and estimating "additional" greenhouse gas reductions from a baseline. When (or if) crediting is allowed, AIJ will provide incentives for foreign donors to fund projects in host countries in return for greenhouse gas credits;
- JI is a very broad term used in the Framework Convention on Climate Change (FCCC): "Parties may implement such policies and measures *jointly* with other parties and may assist other Parties in contributing to the objective of the Convention"(Article 4.{a}),..and "the aim of returning individually *or jointly* to their 1990 levels" (Article 4.2 {b}). JI is also used to refer to project level crediting arrangements between Annex I Parties;
- Emission trading would involve national emission limits (allocation of greenhouse gas units to participating countries) and probably allocation of greenhouse gas units by at least some governments to individual emission sources, plus some form of market in greenhouse gas units.

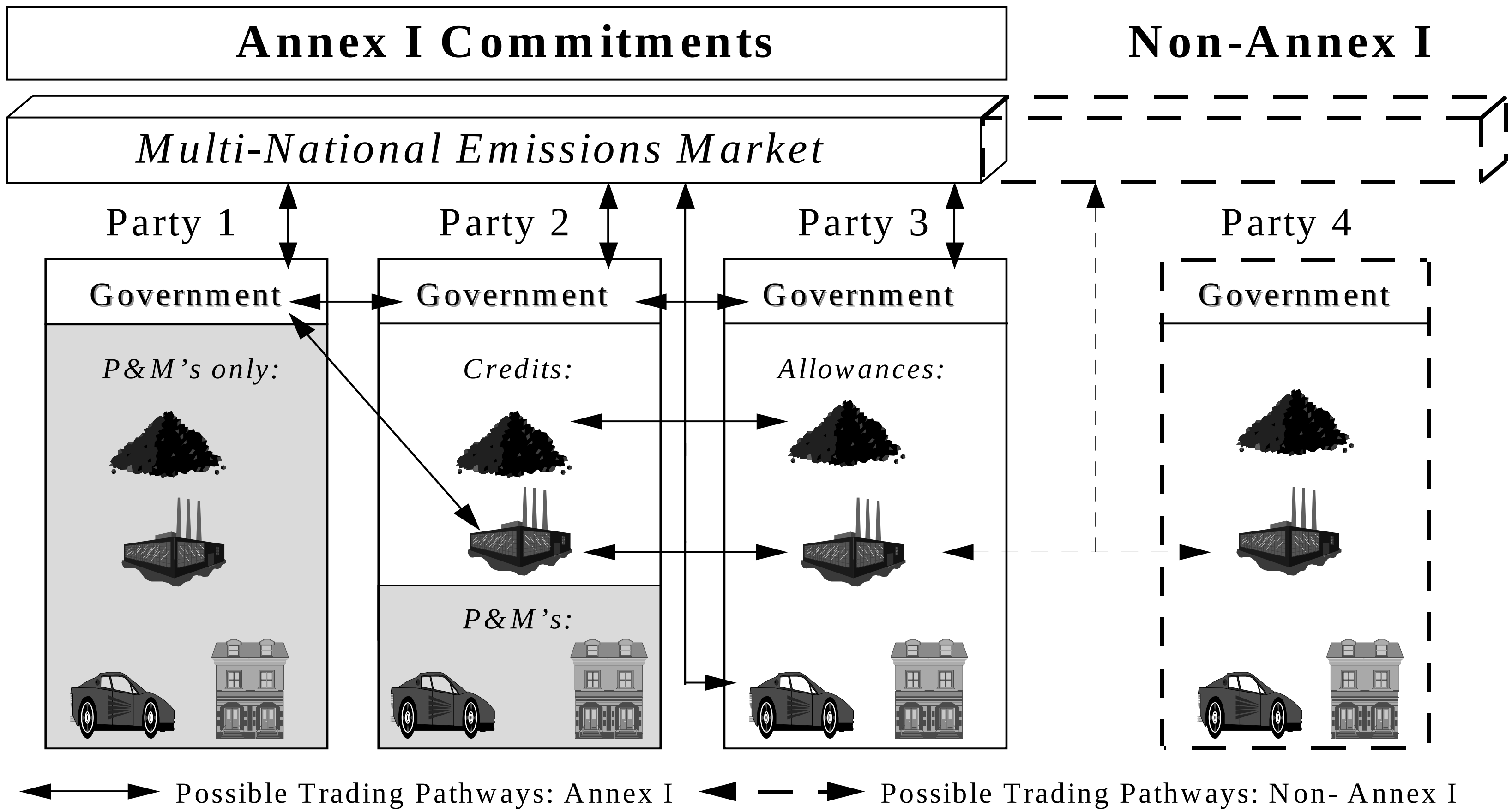
discussed above, are a pre-requisite for emission trading. The possible transactions depicted in the diagram range from bilateral trades among participants (governments, industries, or firms), to trades in a multi-national market for greenhouse gas units where buyers and sellers would not need to interact directly.

**Individual emitters:** Governments may decide to allow individual emission sources such as industries or companies to participate in the international emission trading system (the advantages of this have been discussed earlier in this study). In countries where the government established emission limits for individual emitters (e.g. perhaps through setting up a domestic greenhouse gas emission trading system), these entities could participate in international trading.

Some countries may decide to allocate greenhouse gas units only to major emitters to facilitate monitoring and enforcement of emission limits. Others might decide to auction greenhouse gas units to any bidder, or to allocate greenhouse gas units to every citizen on a per capita basis. Brokers might emerge to act on behalf of small emitters, for example by pooling the greenhouse gas units of several small emitters to form larger packages of greenhouse gas units that would be more attractive to larger participants that were seeking to buy greenhouse gas units.

Some countries may decide that the administrative requirements of establishing a domestic emission trading system and monitoring emissions at the individual source level would be too expensive or complicated. A government might instead tax all emission sources, implement energy efficiency standards, or negotiate voluntary agreements with industry. Individual emission sources would simply comply with domestic regulations, rather than trade in the international emission trading system. Of course, there is nothing to stop any individual or firm from buying and re-selling greenhouse gas units like other commodity but they would not have an initial allocation of greenhouse gas units, and may not be able to purchase greenhouse gas units to meet domestic regulations.

# Possible International GHG Emission Trades



**Countries without national emission limits:** Non-Annex I countries without emission constraints are represented in the diagram by dotted lines. As for Annex I Parties, trading among participants and non-Annex I parties would only be possible if the non-Annex I Parties adopted binding emission limits. Transactions with any participating countries without binding national emission limits would probably have to take place, if at all, on a project or sectoral basis. As discussed above, the project or sector would have to have a binding emission limit and adequate monitoring of emissions.

***Links with other policies and measures***

An international greenhouse gas emission trading system would ideally be able to accommodate and interact with different domestic policies and measures, including domestic emission trading systems. For instance one country may adopt a "cap and trade" domestic trading system with monitoring of emissions at year end, while another might adopt a "baseline and credits" system with emitters earning credits for reductions from their baseline that they can prove they have made (see Appendix 1). Participants in these different domestic trading systems might wish to participate in an international greenhouse gas emission trading system. Different domestic emission trading systems could have implications for the liquidity and enforceability of an international trading system. These factors would need to be considered in designing an international emission trading system.

Governments will wish to retain a high degree of flexibility over their choice of domestic initiatives to meet their commitments because domestic regulatory structures, political feasibility of different measures, and the costs of particular control options vary greatly among Parties. Countries participating in an international emission trading system will have in place, or implement in future, other policies and measures under domestic laws such as emission fees, regulations, standards, or voluntary agreements.[30] Participating countries may have concerns over different treatment of similar industries in different countries and possible effects on national competitiveness.

**Market Mechanisms**

As long as there is profit to be made, a variety of market mechanisms will emerge to facilitate trading. A number of existing market mechanisms such as stock exchanges, information services, and payment mechanisms could be used for emission trading. Other mechanisms may need to be set up, or could develop in response to market needs. As in other commodity markets, a variety of market variations would emerge with real-time markets for immediate delivery of greenhouse gas units, perhaps with a five day settlement period, futures trades (agreements between buyer and seller to purchase/sell a specified number of greenhouse gas units at a specific price at a specified future date), and contracts or "options" to buy or sell at a future date. The diagram below illustrates some market mechanisms (together with monitoring mechanisms) that may be needed in an international trading system, including: brokers; organised exchanges; and information services.

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30 For example, in the US CFC phaseout programme, a tradeable permits system, an excise tax on CFCs, and other policies worked together. Measures for CFC phaseout included: the Golden Carrot system provided an incentive for technology innovation through utilities pooling funds from their efficient refrigerator programs to create a $30 million financial prize for the manufacturer that could develop and distribute the most energy efficient non-CFC refrigerator in the shortest time at the lowest cost to consumers; CFC recycling at service stations; government military procurement rules; and the Clean Air Act Amendments of 1990. New Zealand has suggested that a combination of tradeable certificates and a carbon charge might be feasible for a domestic $CO_2$ reduction programme, with a negative charge or positive credit for $CO_2$ sinks (New Zealand Ministry of Environment, 1996 p. 88.)

*Brokers:*

Brokers are "middlemen" who bring buyers and sellers together, and help participants make bilateral trades or to trade on an exchange. Brokers are specialists and can reduce the transaction costs that can be incurred if buyers and sellers have to find each other and negotiate the terms of each trade. Particularly in the initial stages of an emission trading system when the volumes traded were small, trading might take place bi-laterally or through brokers rather than through organised exchanges. If all greenhouse gas units were not identical, specialised knowledge of the countries or industries from which the greenhouse gas units came might be needed, in which case trading would be more likely to take place through brokers than exchanges.

*Organised exchanges:*

Exchanges where participants can buy or sell greenhouse gas units would emerge to serve a more "liquid" market with a larger volume of trading. Exchanges match willing buyers and sellers, improve market liquidity, provide information on prices which can help price convergence, and can provide or require standard contracts.[31] There could be many different greenhouse gas units exchanges in different regions and countries. Exchanges could hold annual auctions which would encourage trading, reassure new participants that they will be able to enter the market, and assist in establishing a market price for units. Exchanges might require accreditation from an international body to ensure they meet minimum requirements such as information sharing on quantities and prices of greenhouse gas units that are traded.

*Bulletin Boards:*

Information services would be likely to emerge, such as newsletters and electronic bulletin boards quoting prices and quantities of greenhouse gas units sold. This information would assist the market to function smoothly by facilitating price convergence, and providing greater certainty over the value of emissions reductions and tradeable greenhouse gas units. Standard documentation, such as standard greenhouse gas unit transfer forms, confirmation notices and other accounting documents, would also facilitate trading.[32]

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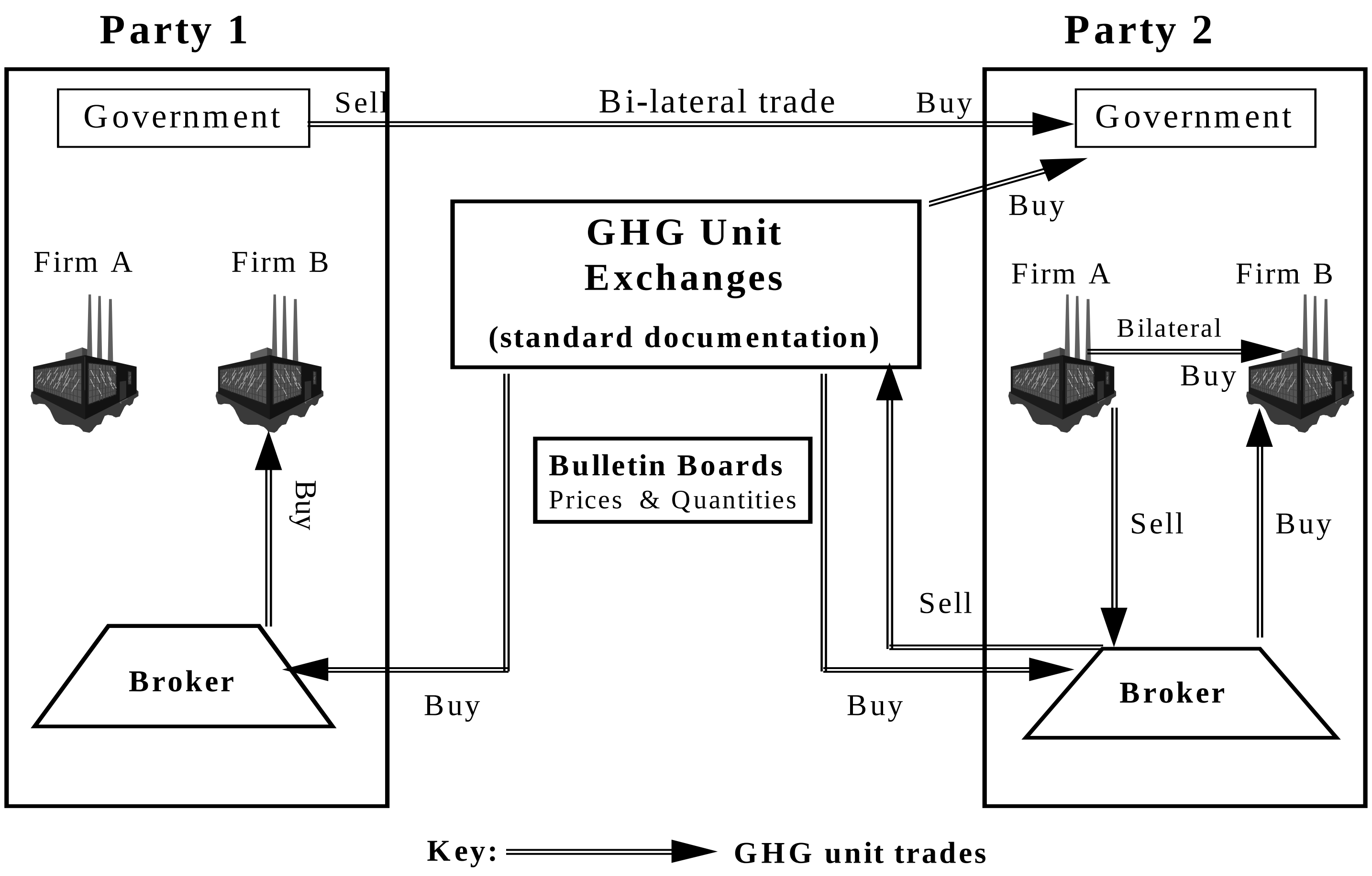
[31] UNCTAD 1994, p. 65

[32] UNCTAD 1994 p. 64

# Possible Market Mechanisms



*Liability provisions:*

Certain requirements would need to be fulfilled to trade through market mechanisms. For trading in stock exchanges, companies must agree to undergo financial audits, and disclose information. A government guarantee could be required for the greenhouse gas units sold from some countries, as with other financial investments. Brokers' reputations would be at stake if they sold permits that were not valid, so reputable brokers could be expected to take precautions or to not buy permits from countries with poor monitoring, or to require proof that the greenhouse gas units were valid. For greenhouse gas unit trading, as with trade in other commodities, there could be requirements for the sellers to show that the units are valid before they could be sold through the exchange. However, verification of every greenhouse gas unit that is traded would be expensive, time consuming, and would hamper the development of a fully liquid market.

Mechanisms or systems to encourage compliance and clarify who is liable if cheating is discovered would increase confidence in the market. Institutions that clarify liability already exist and could be used to facilitate the development of the greenhouse gas emission market. There could be liability clauses in contracts to settle the question of who should pay for the greenhouse gas reductions in cases where the greenhouse gas units were not valid. In these contracts, brokers or exchanges might be partially or fully liable for permits sold through their services, sellers could be liable, or buyers could be liable if traded greenhouse gas units were proved not to be valid. These would probably be natural developments of a more liquid market. It may be necessary to agree to settle liability disputes through a procedure agreed by participants.

It is possible that some international mechanisms may be needed to provide a number of other functions, such as:

- to act as a market of "last resort", keeping a reserve of greenhouse gas units for those who need assurance they will be able to enter the market, to sell excess credits or allowances in an end of period spot market, or purchase if they have insufficient greenhouse gas units to cover emissions above their commitment level;

- to authorise existing exchanges (e.g. New York stock exchange etc.) or accredit new exchanges to conduct organised trading markets.

**Monitoring and Compliance**

The ability to trade emissions units internationally will depend on participants being able to account for their emissions and greenhouse gas units in a way that can be verified by the international community. An emissions trading system without accurate accounting of emissions could result in greenhouse gas units being transferred without compensating reductions being made, in which case the trading system may not help limit emissions.[33] Any uncertainty over the validity of units would increase the effort required, and costs incurred, by participants to satisfy themselves that the greenhouse gas units they wish to purchase are valid. Uncertainty over the validity of units could also reduce incentives for trading as potential sellers might keep a buffer of extra emissions units to cover their own possible needs, and potential buyers might fear paying too much for units that could turn out to be less valuable or invalid. The implication is that in any trading system only verified (and by definition verifiable) emission units could be traded: "Nothing should be traded that cannot be measured, recorded, and reported, or trading becomes a shell

33 UNCTAD 1994, p. 5

game."[34] Enhanced compliance may be needed for any legally binding commitment that may be agreed at COP3 in December 1997, so the cost of compliance would not be completely due to the requirements of a trading system.

The monitoring requirements that would be needed for ensuring compliance with emission limits in an international emission trading system include:

- information collection and reporting;
- audit and review; and
- enforcement.

Each of these elements is discussed briefly below.

***Information collection and reporting***

An international emission trading system will depend on the ability to account for national emissions. All Parties are required to submit an inventory of greenhouse gas emissions. It would be simplest to establish the main monitoring function at national level, through national monitoring mechanisms accredited by the international community and charged with accounting for national trades and national emissions. Recording greenhouse gas unit trades and enforcement of individual emission sources could also be done through national legislation and enforcement mechanisms.

National inventories (based on the IPCC inventory guidelines[35]) could be used as a basis for estimating and reporting greenhouse gas emissions under a trading system to ensure that net emissions in each participating country equal the greenhouse gas units held. The accuracy of greenhouse gas inventory estimates from Annex I countries is affected by the accuracy of the inventory methodologies, whether countries have developed methods better suited to their specific circumstances, and the availability and quality of national "activity data" (data on activities that create greenhouse gas emissions) and emissions factors. The UNFCCC compilation and synthesis noted that problems of transparency and methodological problems were mainly the result of lack of experience in preparing inventories and imperfections in the guidelines.[36]

Experience gained from carrying out inventories of emissions will improve as estimates are carried out for subsequent national communications. Methodologies for estimating greenhouse gases are also being improved through the IPCC/OECD/IEA inventory project. The guidelines for the preparation of national communications by Annex I Parties (revised at COP2) require information to be provided on $CO_2$, $CH_4$, $N_2O$, PFCs, HFCs, $SF_6$ and on the indirect greenhouse gases CO, $NO_x$ and NMVOCs. In addition, these guidelines now require Parties to provide the worksheets including all the assumptions used to estimate $CO_2$ emissions from fossil fuel combustion.[37] For other greenhouse gases and sectors Parties are required

[34] Kete, OECD, 1992, p. 102

[35] These guidelines have been developed under the IPCC/OECD/IEA Programme on National Greenhouse Gas Inventories

[36] FCCC/CP/1996/12/ Add.1 p. 21

[37] FCCC/CP/1996/ L.13/Add.1

to report transparently with enough information to enable a third party to reproduce the estimates. The IPCC, in its latest round of guidelines, is proposing that countries should be requested to submit worksheets showing the main assumptions used to prepare their inventories. Although these reporting instructions and methodologies for inventories provide a basis on which to build reporting requirements for an international emission trading system, in their present form they may not be sufficient to ensure compliance within an international trading system. Additional reporting requirements might be needed to provide certainty among participants that greenhouse gas mitigation action, on which trading of greenhouse gas units is based, is actually occurring.

In designing the international trading system certain common methods and reporting formats should be considered as requirements for participants to be eligible to join the trading system, such as:

- comparable methods for estimation of emissions;
- comparable methods for setting emission baselines for individual emission sources;
- common reporting formats for making information on emissions and greenhouse gas unit holdings accessible to other countries and the public.

Countries who want to trade would need to take on the monitoring, reporting and compliance requirements of the trading system. The benefits from participating in an international emission trading system would be a strong incentive for prospective participants to comply with agreed trading 'rules' such as these.

***Audit and review***

International accounting of emissions would be required to compile information on trades and emissions by each Party and to ensure that they were in compliance with emission limits. The current UNFCCC monitoring function uses a combination of information, reporting and verification: self-reporting through national communications following UNFCCC guidelines on national communications; a compilation and synthesis report which compares the data submitted in national communications and supporting material, presented in a way that is easily accessible to the international community; and reports from in-depth reviews of national communications involving country visits. The current UNFCCC reporting and review mechanisms may need to be altered, and additional monitoring mechanisms may be needed. The objective would be to ensure a credible and fair trading system with verifiable greenhouse gas emission reductions. For example, additional resources, expertise, and consistency between review teams may be needed as well as co-operation from the country in providing the necessary information to ensure that the emissions accounts are thoroughly vetted.

The minimum information that would have to be provided for the reviews would be national emissions of each greenhouse gas included in the trading system and for all sources and sinks covered by the trading system, and the national sales and purchases of greenhouse gas units to other countries. An annual accounting of emissions and greenhouse gas units could be carried out for each participating country (with more frequent accounting if/when the frequency of reporting increased). This information would be provided to each participating country (who would in turn audit individual sources) and would be followed by a "true up" period. During this period, participants with too many emissions in their account could sell or bank their surplus greenhouse gas units and those with too few could buy. A verified emissions account would then be issued for the period. Based on the emission accounting and verification process, sanctions could be imposed for non-compliance.

Standard forms or reporting formats would facilitate the review exercise. The frequency of reporting would need to be carefully considered, weighing the cost of information against market participants' need for certainty that emissions commitments are being met. Reporting requirements are not unique to trading, however. Current inventory reports are submitted annually, and could provide the basis for reporting emissions and greenhouse gas units to the international community. The frequency of reporting could increase, if necessary, as domestic reporting systems improve.

Given the financial value of greenhouse gas units, the importance of accurately estimating and verifying greenhouse gas emissions would be much higher than at present. Participants would be very concerned to ensure that others were not falsifying greenhouse gas units or the associated greenhouse gas emission reductions (whether on purpose or by mistake). Verification of emission reductions (and therefore surplus greenhouse gas units) prior to trading would provide greater certainty in the validity of the greenhouse gas units and so may lower transaction costs compared to an "ex-post" emission accounting process. While an "*ex ante*" system would guarantee the validity of greenhouse gas units traded, an "*ex post*" system would only catch mistakes or cheating long after trades had occurred.

***Enforcement***

At present, Parties rely on moral suasion and adverse publicity, which does not provide strong incentives for compliance. This level of enforcement would not be sufficient to ensure confidence in a trading system. There would be little incentive for a participant to purchase greenhouse gas units if the cost of non-compliance were less than the cost of the units, or if the likelihood of penalties being imposed were low. Uncertainty over the actions of other participating countries would reduce confidence in the trading system. There are different levels of enforcement possible, depending on the desired stringency of enforcement and the cost of enforcement that participants are willing to bear. Parties could agree to impose fines or penalties for excess emissions, reduce future emissions allocations, prevent non-compliers from participating in international trading, or use the UNFCCC multi-lateral consultative mechanism to resolve disputes on a case-by-case basis.

For individual emission sources that are participating in the international emission trading system, the main institutions for enforcement are likely to be at the national level. Countries could be required to enact domestic legal mechanisms for enforcement of greenhouse gas emission limits on individual emission sources under their jurisdiction before entering the international trading system, in order to operationalise the legal enforcement of trades. At the international level, sanctions on governments are more difficult. International legal mechanisms for enforcement are more difficult to use and less likely to be effective than national laws for domestic emission sources. In some instances, economic sanctions have been used to pressure countries to comply with international agreements (e.g. provisions for this in World Trade Organisation), but in many instances, breaches in agreements are not enforced because of the cost and uncertainty of success. Of course, stringent and expensive enforcement may be "...less necessary when the agreement being enforced has broad... support among countries."[38]

International emission trading could create economic incentives for effective national enforcement and international compliance. If regulators in importing countries disallowed the use of greenhouse gas units from countries (or firms in these countries) with lax enforcement or that had not complied with reporting obligations or national commitments, the market price of greenhouse gas units from such sources would decline. An analogy in bond markets is that bonds from countries with very large debts trade at a

[38] UNCTAD 1994, p. 7.

discount. A credible trading system would therefore provide an economic incentive for effective enforcement of compliance with international commitments.

## Administration and transaction costs

### *System administration costs*

The design of a trading system can greatly affect the administrative costs. For example, an allowances system such as the $SO_2$ trading in the US required a great deal of negotiation and government involvement to reach agreement on allocations of allowances, but the ongoing administrative costs of the system are quite low (see Appendix 2). If each project must be examined and approved before greenhouse gas units can be traded, the system could have higher on-going administrative costs. Project-by-project approval of emissions credits could be avoided if approved methodologies are used to calculate the greenhouse gas benefits so that annual monitoring to ensure compliance would be sufficient.

In an international emission trading system participants would be interested to ensure international oversight or monitoring of emissions and trades. Many analysts emphasise that the role of government in national trading systems should be kept to a minimum.[39] For $SO_2$ emission trading in the US, for example, the government role is simply to ensure compliance on an annual basis, not to approve individual trades. For some potential participants in an international trading system, for example small countries and countries undergoing the process of transition to a market economy, it is very important to build on existing institutions to minimise the cost of monitoring and administration of the system at the domestic level.

If the central administration function could be funded by a greenhouse gas unit levy. The levy would provide an incentive for participants to ensure the administration of the system were as efficient as possible. Participants would then be more likely to co-operate, provide data, and take over any responsibilities they can carry out at lower cost.[40]

### *Transaction costs*

Transaction costs are the costs incurred by participants (both buyers and sellers) in making a trade, in order to initiate and complete the transaction. Transaction costs include both the money spent to initiate and complete a trade, and opportunity costs - the lost time (through delay) and resources (e.g. money, managerial attention) - that could have been devoted to the next best opportunity for that participant.[41] The greater the administrative or other effort required for making trades, the higher the costs either buyers or sellers or both will face for sale/purchase of units. Some of the main types of transaction cost are:[42]

- search costs (the cost of finding partners to trade with, such as fees to banks, brokers, exchange institutions);
- negotiation costs (the cost of reaching an agreement e.g. on price, conditions of trade);
- approval costs (delays, fees and other costs incurred in government approval processes);

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39 e.g. Dwyer, OECD 1992, p.21

40 OECD 1992 p. 120

41 OECD 1996 p. 14

42 Foster and Hahn 1994, Stavins, 1994, McCann 1994, OECD 1996 p. 14

- monitoring costs (efforts by participants to verify their adherence to the terms of the transaction)
- non-compliance costs (costs/penalties incurred when non-compliance is detected);
- insurance costs (the indirect costs associated with the uncertainty of completing a trade).

High transaction costs will make an emission trading system less effective.[43] Transaction costs are often a hidden aspect of implementation, but they may greatly reduce the cost savings that are potentially achievable by reducing the number of trades that are made. Transaction costs are likely to be high in the initial phases of a trading system. Experience from the United States indicates that these costs rapidly decline after the first few years of a program as intermediaries emerge and regulators, industry, and brokers come to better understand and master the idiosyncrasies of the trading program.

The transaction costs of trading can be reduced through the careful design of parameters such as the definition of the unit of trade, the institutions created or adapted to facilitate trading, and the type of monitoring requirements imposed (these elements are discussed earlier in the paper). For example, institutions such as brokers, permit exchanges, and an institution such as an international emission accounting institution can reduce participants' search and negotiation costs by reducing the effort required by investors to find and contact trade partners. If requirements for approving trades are kept as simple as possible, while at the same time allowing adequate verification and oversight, approval costs will be reduced. A market that is designed to give participants a high degree of confidence in the system can reduce insurance costs. In contrast, in a market that is perceived to be risky, trades must be accompanied by letters of credit, legal opinions, and other intermediaries that all raise the costs of trade.

There is some empirical evidence of the effects of transaction costs on different trading systems. Emission Reduction Credits (ERC) trading in the US (see description in Appendix 2) has had a relatively high level of transactions costs. These transaction costs are caused partly because the pollutants that are being addressed have acute local effects (e.g. CO, $SO_x$, and $NO_x$), which necessitated many regulatory requirements to prevent unacceptably poor local air quality. Regulators had a high degree of discretion over approval of trades which appears to have raised transaction costs because many regulators did not fully support emissions trading as a tool to control pollution.[44] Apart from the search and negotiation costs to trade ERCs, firms face approval costs in the form of five to twelve month delays to obtain government approval in advance for each trade. Administrative fees are charged by the regulatory body, and there are substantial monitoring costs associated with preparing supporting documentation for each trade.[45] greenhouse gas emission trading may face fewer such concerns because most greenhouse gases have no local effects and are rarely covered by existing regulations. Many of these transaction costs are inherent costs in the regulations on which the trading system is over-laid. Nevertheless, these examples are instructive for thinking about the types of transaction costs that need to be avoided in designing an international greenhouse gas emission trading system. A lesson from this is that requiring advance regulatory approval of trades on a case-by-case basis inhibits the effectiveness of the trading system.

Another United States emission trading system, RECLAIM, (which began as credit trading and has become an allowance system), has clear rules about trading which limit the need for legal advice, and regulatory intervention, and continuous monitoring requirements that create monitoring costs for

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43 Tripp and Dudek, Institutional Guidelines for Designing Successful transferable Rights Programs, Yale Journal on Regulation, Vol. 6, No. 369, 1989 p. 377.

44 Dwyer, in OECD 1992

45 Foster and Hahn 1994, p. 23

participants, but they make quantification and verification of emissions easier and so lower the administrative costs for regulators.

The US $SO_2$ allowance trading system benefited from experience gained through these earlier emission trading systems and was designed to have low transaction costs. Search and negotiation costs in the $SO_2$ trading system are probably lower than in the ERC system, partly because brokers and information services have emerged, and also because annual auctions enable any participant to purchase/sell allowances relatively easily. Approval costs are low as there is limited government oversight of trading. Emissions from each participant are tracked on an annual basis (after the trades have been made) rather than for each trade. There is a high degree of confidence in the trading system so indirect “insurance costs” associated with the uncertainty of completing a trade are also low. These low transaction costs are achieved through the imposition of monitoring requirements: a continuous emission monitoring system (CEMS) is required for each participant in the trading system regardless of whether they actually trade. Participants also face high non-compliance costs: a high fee is charged for any excess $SO_2$ emissions that are not covered by allowances.

The United States is establishing a new $NO_x$ emission trading system. In this system, reporting is required from each participant to provide assurance that emissions limits are being complied with. Monitoring costs are being kept low by relying on existing fuel monitoring equipment that is already installed at each source.

The rules governing the trading system can have a dramatic effect on transaction costs.[46] Some of the transaction costs discussed above are the result of underlying regulatory requirements rather than the trading system itself.[47] Any international greenhouse gas emission trading system will not take place in a vacuum. The design of the trading system will have to take into account limits imposed by existing regulations or policies implemented for other reasons which may limit the effectiveness of the trading system through increased transaction costs. Even at an international level, where existing regulations are few, current or future WTO rules may affect the transaction costs in international trades and domestic regulations will also play a role (e.g. taxes, environmental standards).

Any set of policies and measures to limit greenhouse gas emissions will involve monitoring and enforcement. The important question is the total cost of meeting a particular commitment. The experience with existing trading systems is that the total costs of emission reduction can be much lower than conventional policies, even if administration and transaction costs are high.

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46 Foster and Hahn, April 1995, p. 21

47 California’s tradeable emissions programme supplements an existing command-and control system and so “is not a fully functioning market in which all firms may freely trade emissions to achieve a cost-effective distribution.” (Dwyer, OECD 1992, p. 42). RECLAIM in the US was developed with a variety of special regulatory and legal design limits. For example the California District was prohibited from using banking as an element in its program design by the California Clean Air Act (OECD, 1996). For $SO_2$ trading, traditional electric utility regulatory oversight of state-based utility commissions is considered to have retarded early market development. The ERC market developed poorly largely because of legal and regulatory uncertainties that characterise its history such as confiscation of banked credits by regulators, frequent amendments to the regulations, and geographical segmentation (Foster and Hahn OECD ENV/EPOC/GEEI(96)6 p. 57).

## OTHER ISSUES

### Possible barriers, political feasibility

Establishing an international emission trading system will not be simple. A wide range of impediments are possible. Possible impediments include: uncertainties due to lack of experience with international emission trading systems; lack of confidence in other countries' monitoring systems; or industry opposition to government control and involvement in the trading process.

There could also be a concern that rich countries would purchase greenhouse gas units from other countries, hence neglecting to implement (or make progress towards implementing) politically difficult, but cost-effective, measures at home. On the other hand, the cost of purchasing greenhouse gas units could strengthen movements to implement previously unpopular measures at home. To reduce concerns that countries will avoid taking cost-effective actions at home, the percentage of a country's national commitment that can be traded could be limited (although this would have adverse affects on the liquidity of the trading system - i..e. the number of trades).

### Market power issues

Market power could arise in the form of a few large buyers of greenhouse gas units, a few large sellers of greenhouse gas units, or a few participants that dominate the market through the size of their greenhouse gas unit holdings. It is likely that some participants will have large holdings of greenhouse gas units. Some participants with large holdings might be large buyers or sellers of greenhouse gas units (this depends on how strict the initial emission limits are for each participant compared to the cost of greenhouse gas mitigation). The level of greenhouse gas emissions from different countries is one indication of whether a country may have market power.[48] The participation of many private sector participants could reduce the potential for abuse of market power. However, even with many small participants, the system might still face abuse of market power by large participants such as governments trading on behalf of their country.

The potential for market power can be influenced by the way the emission trading system is designed, and by the participants that are allowed to trade greenhouse gas units.[49] A market with a large number of diverse participants, in which the greenhouse gas units can be easily traded, will be less susceptible to market power by individual participants. For this reason it is important to allow greenhouse gas units to be bought and sold by any individual or entity. Countries with the administrative capacity to do so should be encouraged to develop domestic emission trading systems that are consistent with the international trading system to facilitate the participation of individual sources in the international trading system.

48 Illustrations of emission limits for Annex I Parties under three different allocation rules are provided in Appendix 3.

49 Westskog, 1996 p. 86

Multiple sources and different greenhouse gases in the trading system would also help reduce the potential for market concentration. A mandatory auction of some allowances would reduce the effect of possible hoarding of greenhouse gas units by net sellers. A strategic reserve or "buffer" of greenhouse gas units held by an international entity and perhaps auctioned periodically would also reduce the ability of large participants to prevent new entrants from purchasing greenhouse gas units or to drive prices up by hoarding greenhouse gas units.

**Phasing**

It would be difficult to implement a system that covered, from the outset, all greenhouse gas, all sources and sinks, and all Parties. Such difficulties would cause delays, during which time opportunities to trade would be lost. An international emission trading market would be likely to develop gradually over time towards more fully comprehensive trading of different greenhouse gases, evolving into a system with many trades, many participants, and hence greater cost savings and flexibility.[50]

The number of participants might start small to avoid uncertainties of trading with participants in countries that could not fully verify their emissions. The number of participating countries could increase as more countries opt to take on appropriate monitoring and other requirements. Domestic trading systems are also likely to develop over time, which would facilitate private trades among individual emission sources. The number of greenhouse gases covered by an international emission trading system could also gradually expand from fossil fuel derived carbon dioxide to all greenhouse gases. Ideas for phasing in an international emission trading system are given below. These would not necessarily be separate options; they could develop together.

- A system of bilateral trades among governments could be established where countries with emission limits trade these commitments among themselves. This is essentially how the European Union (EU) commitment was envisaged, with some countries reducing emissions further than necessary, while other countries emit more. Making these informal agreements more concrete and binding could be a first step towards emission trading.

- A trading system could begin with a few countries with good emission monitoring but sufficient diversity of greenhouse gas mitigation costs to make trading worthwhile. A limited number of participants during the negotiation and early implementation phase would enable all potential participants to learn more about how such a system works.[51]

- Existing national market and monitoring institutions could be used while experience is gained on trading, before any international institutions deemed necessary are set up. The effectiveness of national institutions should be evaluated to determine whether they are sufficient, before considering whether international institutions would be necessary.

Phasing, although necessary, would have to be carefully designed to avoid unnecessary distortions or limitations to participants' flexibility to mitigate greenhouse gas emissions in the most cost-effective way. In the US $SO_2$ allowance trading system (see Appendix 2), participants in the first phase hold excess

[50] UNCTAD 1994 p. 11

[51] Hahn and Richards, (1989).

supply of $SO_2$ allowances, but trading is limited by the fact that second phase participants do not yet have emission limits so the full demand for allowances not yet exist.

**Impacts on other countries**

Tradeable greenhouse gas units separate the financing of emissions control from the implementation of control. They are an effective means for transferring resources from developed to developing countries if they choose to adopt emission limits and other pre-requisites to participate in the trading system. In addition, by reducing the overall costs of greenhouse gas mitigation, emission trading could reduce trade and other negative impacts of Annex I countries' mitigation policies on non-Annex I countries.

Under any arrangement where some Parties have emission limits and others do not, carbon "leakage" may be a concern (i.e. reduction strategies pursued in one region could result in an increase in emissions in another region).[52] Leakage may occur in a system of emission limits without trading, for example, because productive activity may move from countries where the emission limit is more difficult to meet to countries where the emission limit is easier to meet.[53] International emission trading would reduce emission leakage by reducing the disparities between countries in the cost of meeting emission limits. In addition, to the extent that non-participating countries (those without an emissions limit) decide to enter into the trading process, trading will provide incentives for non-participating countries to pursue greenhouse gas abatement measures, thereby discouraging leakage.

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[52] IPCC SAR, WG III, chapter 11, section 11.6.4, pages 423-426.

[53] The extent to which environmental standards or emission limits influence industry location is controversial. Many factors play a part in industry decisions to re-locate, including comparative advantage in energy intensive goods, energy prices, and terms-of-trade impacts (OECD, 1995 p. 19).

## CONCLUSIONS

Greenhouse gases are well-suited to international trading because the location of greenhouse gas emission reduction does not affect the climate. International greenhouse gas emission trading among countries with emission limits would enable them to achieve compliance with national emission limits at lower cost, while allowing countries full flexibility to reduce domestic emissions in ways that best suit their national circumstances.[54] Certain features of emission trading, such as banking, could also provide flexibility over when greenhouse gas mitigation can take place and provide an incentive for early action to reduce greenhouse gas emissions where this is cost-effective.

Difficulties in monitoring, reporting, and audit of emissions might make it impractical to implement an emission trading system covering, from the outset, all greenhouse gases, all sources and sinks, and all Parties. Implementing a fully comprehensive system would cause delays, during which opportunities to trade would be lost. An international emission trading market would be more likely to start with a limited number of participants to ensure simplicity and avoid uncertainties of trading with participants in countries that could not adequately verify their emissions. For the same reason, an international emission trading market might start with only greenhouse gases that can be adequately monitored. The market could then evolve to become more fully comprehensive and more cost-effective. New participants could join as their monitoring capacities improved. The greenhouse gases covered by an international emission trading system could gradually expand from fossil fuel derived carbon dioxide to all greenhouse gas. Existing national market and monitoring institutions could be used to gain experience on trading, while considering the need for, and design of, any additional international institutions for a longer term, more comprehensive system.

It is important to note that some of the main complexities in designing an international greenhouse gas emission trading system will need to be resolved regardless of whether a trading system is set up. These include:

- the setting of legally-binding commitments by the COP;
- a decision over whether to allow banking and borrowing of emissions;
- a decision over whether and how Parties' commitments should accommodate the comprehensive (all greenhouse gases) and net (sources and sinks) approaches; and
- the inventory, reporting, compliance and enforcement methodologies and mechanisms by which these commitments are judged to have been met.

Further work is needed on the issues discussed in this study to improve understanding of emission trading and to share ideas on key design issues if workable options for international emission trading are to be developed.

[54] IPCC 1995, SAR, WGIII p.417; IPCC Technical Paper on Policies and Measures p.71, UNCTAD 1994, UNCTAD 1996, OECD 1992.

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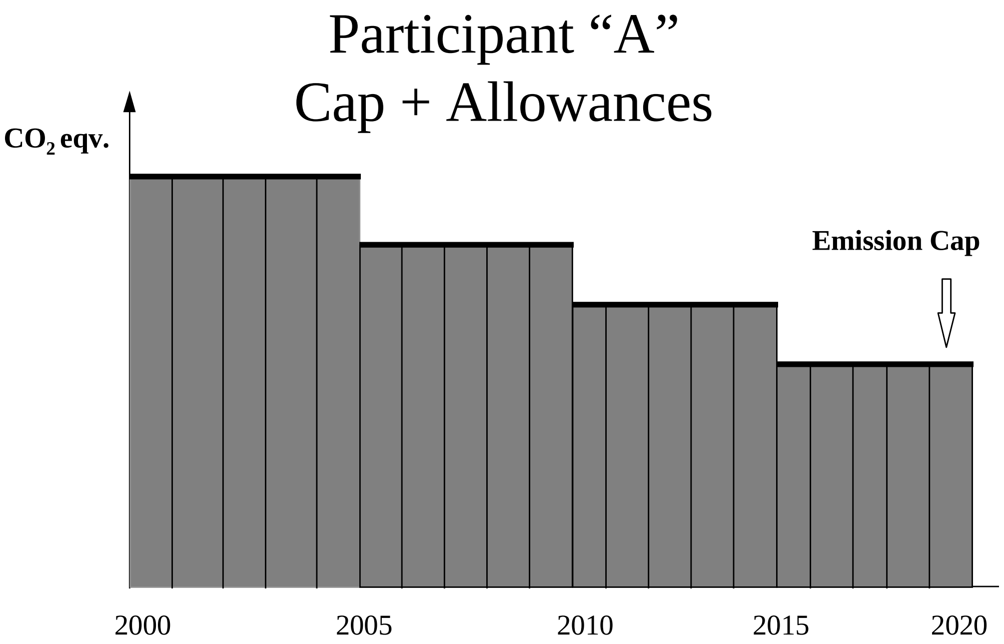
## APPENDIX 1: EXPERIENCE FROM OTHER TRADING SYSTEMS

**"Cap and Trade" versus "Baseline and credits"**

**"Cap and trade"**

"Cap and trade" is one form of emission trading that is often referred to.[55] The US $SO_2$ allowance system is an example of a "cap and trade" system at domestic level. The example below shows how this type of system might apply to international greenhouse gas emission trading:



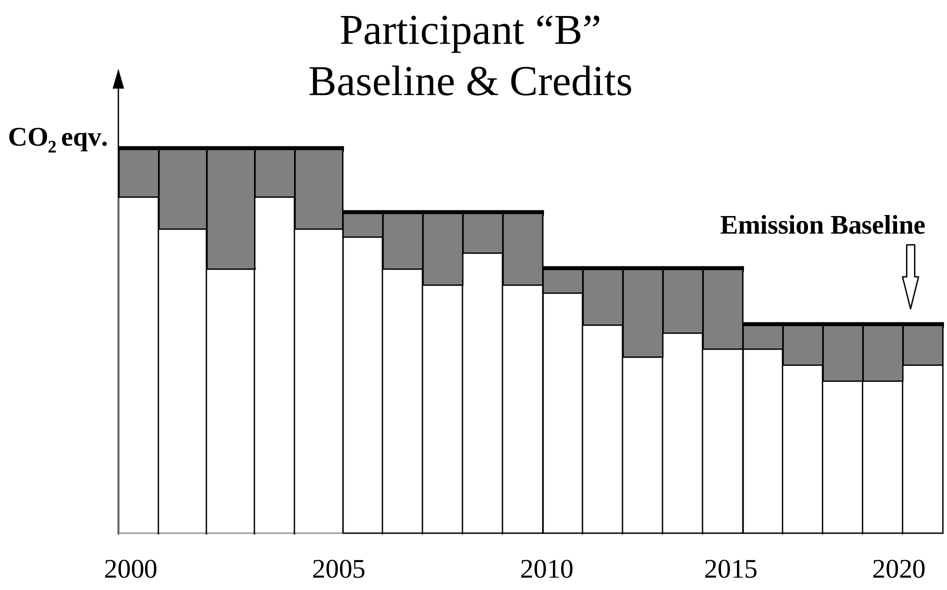

The cap illustrated above is a legally binding limit on annual emissions for Participant A which decreases every five years (a cap could be set at a constant level for each period, or even rise depending on the overall emission limit desired, or an historical baseline emission trend could be used as the basis for determining the cap). Assuming participant A were a country, this cap would represent the annual greenhouse gas emissions that the country was allowed to emit. The shaded area depicts the greenhouse gas emissions that the country can emit, and the greenhouse gas units that are allocated to the country that

[55] Another term for an emission constraint that is often referred to is an "emission budget" - this concept is not fundamentally different from the cap concept.

represent those greenhouse gas emissions. If emissions are reduced so that they are lower than the agreed cap, the greenhouse gas units representing these emissions reductions can be sold to another participant, or saved for future use. The term "allowances" is often used for the greenhouse gas units that represent emissions participants are allowed to emit. Any greenhouse gas units that are not needed to offset emissions can be sold to other participants. If a country sets emission limits for individual sources, by allocating or auctioning greenhouse gas units to them, then these sources could participate in both a domestic and international trading system.

**"Baseline and credits"**

Another well known trading concept is "baseline and credits", where the emission limit is a baseline and the greenhouse gas units are reductions from this baseline that are often referred to as "credits". The baseline illustrated below is a limit on annual emissions for Participant B, which is the same as the cap in the diagram above - just to show that a baseline can be identical to a cap. The baseline could be a fixed level of emissions (a flat line) or even increasing over time, as could "caps". However, baselines may also be emission limits where the total emission level is not completely fixed, nor legally binding. For example the baseline could be $CO_2$ per capita, $CO_2$ per GDP, or some future projection of greenhouse gas emissions from which reductions can be verified as "additional". The shaded areas are the difference between the agreed baseline emission levels and the actual emissions. The greenhouse gas units representing the shaded area of reductions from the baseline can be traded, and are typically referred to as "credits". If the country chose to set baselines for its individual sources, then these sources could also earn credits from their government for reductions from their baselines and so participate in both domestic and international trading systems.




**The US $SO_2$ Allowances Programme**

The aim of the $SO_2$ trading system in the United States is to reduce acid rain caused by $SO_2$ emissions mainly generated by coal-fired electric power plants. The Clean Air Act of 1970 introduced tight emissions standards for all newly constructed plants in the US, and this was complemented by legislation in individual States in order to meet National Ambient Air Quality Standards (NAAQS), including for $SO_2$. These standards resulted in greater use of end of pipe desulphurisation techniques and switching to lower sulphur coal, but acidification problems remained, mainly because utilities did not retire their old plants.

Harmful acidification is caused by geographic concentrations of $SO_2$ so it does matter where and to some extent when emissions occur. However, the US $SO_2$ trading system operates without regard to spatial distribution of emissions - there are no geographical, temporal or other restrictions on trading although there are other air pollutant regulations that limit $SO_2$ emissions at local and regional levels. The $SO_2$ emissions cap is 8.95 $MtSO_2$ per year (about a 40 per cent reduction from 1980 levels). The Phase I programme participants are coal-fired electric utilities, and Phase 2 participants will include existing utility units with an output capacity of 25 megawatts or greater and all new utility units that use fossil fuels with a sulphur content greater than 0.05 per cent. The programme will eventually include around 2 050 electric utility plants. The US system does not include other types of sources such as industrial facilities, motor vehicles, etc.

Each allowance is for 1 ton $SO_2$ in a specific year, with annual allowance allocations for each participant that are set from the time participants they enter the trading system until 2030. Electric utilities are allocated allowances based on historical Btu production levels. New sources are allocated allowances based on an agreed formula. After 2000, new sources will have to purchase allowances on the market. Allowances can be traded to any party anywhere within continental US and may be "banked" for use in future years.

A guiding principle in designing the $SO_2$ trading system was to minimise the role of government in the market. The US Environmental Protection Agency (EPA) holds an annual auction of about 2.8 per cent of the total allowance allocation to deliver signals on allowance prices and ensure allowances are available for new and independent power producers. After only three auctions, it appears the auction may not be needed permanently as over-compliance (therefore availability of allowances for new participants) and price convergence are already features of the market. Precise and accurate measurement of emissions is considered to be a key component of the $SO_2$ trading programme (Kete, 1992, OECD, p. 92). Measurements of $SO_2$ emissions are taken from continuous emissions monitoring equipment that is required to be installed in each unit, which provides data on hourly discharges of emissions to the EPA four times a year. The EPA operates a centralised emissions and allowance tracking system to ensure compliance four times a year, enabling the EPA to measure total annual $SO_2$ discharges.

Participants are allowed to emit above the level of their allowances during the year as long as their emissions account balances at year end. The computerised system to manage the tracking system is no more complex than those used by insurance companies, banks and department stores. Participants are required to notify the EPA when they have negotiated a trade, but individual trades do not have to be approved. If $SO_2$ emissions exceed the number of allowances, statutory penalties are imposed (every excess ton of $SO_2$ emitted incurs a fee of $2000, compared to the estimated marginal cost of reduction between $300 and $800 per ton) plus an automatic deduction of one allowance from the following year per excess ton. Phase I began in January 1995 and required emission reductions from 110 mostly coal burning plants located in the eastern and mid-western states. Phase II becomes effective on January 2000, tightens the annual emissions cap on the phase I plants, and extends the programme to the whole continental US. Allowance brokers, trade association newsletters, electronic bulletin boards have become features of the market. The transaction costs for allowance trades have been quite low.

## Emission Reduction Credits

In the United States, a "baseline and credits" type of system has been used to improve air quality in areas where these federal air quality standards are not being met (so-called "non-attainment areas"). This system allows new industrial activity to set up in the area as long as emissions from the new activity are offset by reductions from other emission sources. The 1990 Clean Air Act contained provisions for using a tradeable permit approach. The ERC trading programme is nation-wide and covers all significant stationary sources of pollution for reactive hydrocarbons, $NO_x$, particulates, $SO_x$, and CO. Trade with non-stationary sources is permitted but limited to ships and fleet vehicles. The greenhouse gas units in this system are called "Emission Reduction Credits" (ERCs).

In this system the baseline emission limits for each participant are the air quality standards that individual firms must meet. ERCs are typically a quantity of pollutant per unit time; for example, an ERC could give the holder the right to emit 1 ton of $NO_x$ per year for as long as the ERC remains valid. ERCs are not valid "in perpetuity", as there is provision for the rules to change if necessary. A firm can create ERCs by over-control, for example, by changing its process of production in order to reduce emissions well below the required air quality limits. The firm can then sell these ERCs to another firm that wants to set up industrial activity. However, there is no scope in this programme for firms to purchase ERCs to enable them to raise their emissions (per unit of time) beyond the air quality limits. If a firm cannot find a buyer for its ERCs, it is able to "bank" these in order to be able to sell them at a later date. However, due to the nature of the ERCs (quantity pollutant per unit time) any years during which an ERC is "banked" is effectively a year during which that ton of pollutant cannot be emitted. Thus "banking" under ERC systems is quite different to the inter-temporal banking discussed in the main text of this study where a greenhouse gas unit saved one year would remain valid for use in future years.

Several distinct types of trade that originated with ERCs trading have become well-known concepts:

- *netting* allows a firm that creates a new source of emissions to compensate by reducing emissions in one of its other plants;

- *offsets* allow new sources to locate in non-attainment areas if they buy ERCs from another firm in the non-attainment area, for example a firm that is closing down or reducing its emissions;

- *bubbles* allow existing firms to choose how much to control emissions from each of their plants as long as the aggregate emissions from all plants does not exceed the bubble limit.

Most trade in ERCs has occurred within firms, such as between two plants owned by the same utility.[56] Because each transaction has to be carefully assessed by state regulators before the ERCs obtain approval as "surplus" (which can take several months), the liquidity of the market is limited and the transaction costs of trading ERCs can be significant, resulting in less cost-effective reductions than could be achieved otherwise. The regulators have to be satisfied that the ERCs are:[57]

- *real*, corresponding to a reduction from the allowed baseline in actual emission levels;

- *surplus*, beyond the required reduction in applicable regulations and permit conditions;

56 Foster and Hahn, April 1995, p. 21

57 NAPA, 1994; Palmisano, 1996

- *quantifiable*, through accepted procedures which are used consistently to measure emissions before and after reductions;

- *enforceable*, leading to a compliance instrument which is legally-binding and enforceable; and

- *permanent*, the reduction should not be temporary, or negated by future increase, but should be assured throughout the life of the emission source.

**ODS trading under the Montreal Protocol**

The Montreal Protocol has proven to be a very effective international agreement for reducing ozone depleting substances (ODS) such as chlorofluorocarbons (CFCs).[58] Under the Montreal Protocol, a schedule to gradually phase-out ODS has been agreed. To achieve this objective, limits on production and consumption of ODS (equivalent to some proportion of the Party's ODS levels in an historic base-year, and decreasing over time) have been agreed for each Party.

For CFCs the limits are calculated as follows:

| CFC limits for developed countries: | CFC limits for developing countries: |
|---|---|
| Reduce 75 per cent relative to 1986 level by 1994 | Reduce by 50 per cent relative to average 1995-97 levels by 2005 |
| Reduce 100 per cent relative to 1986 level by 1996 | Reduce 85 per cent relative to average 1995-97 levels by 2007 |
| | Reduce 100 per cent relative to average 1995-97 levels by 2010 |

Source: UNEP (1995) "Elements for Establishing Polices, Strategies and Institutional Framework for Ozone Layer Protection", p. 8

ODS consumption is defined as production plus imports minus exports. ODS consumption includes: pure or recycled ODS; products containing or made with ODS; equipment requiring ODS for its use. (Pearce, p. 44). Each Party's total production and consumption of ODS is calculated by weighting each ODS by ozone-depleting potentials that are specified in annexes to the Montreal Protocol.[59]

The Montreal Protocol contains provisions for "industrial rationalisation" which allows Parties to transfer all or part of their production limit to other countries (for example as production diminishes, parties may go further than the required limit due to economies-of-scale of ODS production). Small industrialised Parties can transfer all or some of their consumption limit, as long as the total ODS production or consumption levels do not exceed the sum of all Parties ODS limits. Regional Economic Organisations (currently the European Union) are permitted to meet the ODS consumption limits jointly.[60] There are restrictions on trading different ODS e.g. CFCs cannot be exchanged for halons, although some CFCs (11,

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58 Much of the information in this section is from Brack, D. "International Trade and the Montreal Protocol" Royal Institute of International Affairs, Earthscan Publications Ltd, London, and also Kuik, O., Peters, P. and Nico Schrijver (Eds.) "Joint Implementation to Curb Climate Change: Legal and Economic Aspects"

59 Brack, D, 1996, p. 13

60 Brack, D, 1996, p. 16

12, 113, 114, and 115) can be exchanged for each other. After the specified phase-out date, Parties can exceed their production limit by 10 per cent or 15 per cent (depending on the ODS and date) in order to export ODS to developing countries to meet their 'basic domestic needs'; or for 'essential uses' (e.g. CFCs for metered dose inhalers) which must be agreed by all Parties. Surplus ODS can also be stock-piled or "banked" for future use.

Imports from, and exports to, non-Parties are prohibited under the Montreal Protocol in order to prevent "leakage" of ODS from Parties to non-Parties. This prohibition is implemented through national legislation to prevent domestic importers and exporters of ODS from trading with countries that do not comply with the Montreal Protocol ODS limits. These trade restrictions are seen as justifiable and very important for the success of the Montreal Protocol, but they potentially violate the non-discrimination principles of the General Agreement on Tariffs and Trade (GATT).[61]

In some industrialised countries, tradeable ODS permits are used as a way of allowing domestic industry to meet their commitments more flexibly. Often these domestic systems have links to international ODS trading.

In the United States, since 1989, firms have been given ODS limits based on their 1986 ODS levels. Firms have also been allowed to produce 10 per cent over their ODS limit to export to developing countries if sufficient documentation is produced to prove that the chemicals are shipped overseas. Industry ODS limits decline over time, in accordance with the Montreal Protocol phase-out schedule. Between 1989-1995, about 40 trades (approximately 45 million kgs of ODS) were made between US companies and companies in other countries (WRI, 1996, p. 35). This system minimised the administrative costs of implementing the Montreal Protocol in the US and gave companies flexibility in timing their phase out of ODS.

In Singapore, a tradeable permit system has been operating since 1991. In order to trade, a company must register and pay a fee of $240 a year. The government sends out application forms to registered end-users or distributors of ODS to establish their ODS requirements and bid prices (UNEP, 1995, 46). The total national allowance of ODS consumption allowances (based on the Montreal Protocol phase-out plan) is then distributed to registered companies, half by auction and half by allocation (as long as company ODS allocations do not exceed preceding year's consumption of any company). In New Zealand, an "import permit" system has been in place since 1986. Imports of CFCs (and methyl chloroform or carbon tetrachloride) are only allowed by holders of CFC import permits issued by the Minister of Commerce. Trading is allowed between permit holders. No inter-ODS trading is allowed (i.e. CFC permit for CFC permit only).

Governments report to the Ozone Secretariat on their progress in reducing ODS. When one or more Party has a query concerning the legitimacy of a national decision, Parties can be called to a compliance body of the Montreal Protocol - the Implementation Committee. This body considers all questions of implementation and non-compliance. In 1992, a non-compliance procedure was agreed upon which was designed to give maximum opportunities for compliance, as opposed to punishment; the specific list of measures that can be taken includes technical and financial assistance, followed by the issuing of cautions, followed by suspension. In this last case, the country would effectively no longer be a Party to the Montreal

<u>Implementation Committee</u>

- Established by the 1990 by the Meeting of the Parties
- Has 10 members selected from the Parties
- Meets once or twice per year
- Considers questions of implementation and non-compliance

[61] Brack, D, 1996, p. 65

Protocol and would lose access to the ODS market of other Parties, and forego any rights to financial support.

Monitoring of ODS is carried out at the national level. Different countries use different methods to monitor legal production and consumption of all types of ODS, based on records of imports and exports of ODS. The success of monitoring under the Montreal Protocol depends strongly on stable political and economic infrastructures, and on national plans to reduce ODS backed by solid legislation and enforcement. The objective of the Montreal Protocol (phase-out of CFCs in 1996) is being undermined by illegal trade.[62] Domestic legal action is perhaps the only mechanism to discourage this. Because of the difficulties in monitoring production, consumption, and imports of ODS, and confidentiality issues related to trade data, it is difficult to judge just how much illegal trading is taking place. Examples of illegal trading systems are:

- erroneous reporting of ODS exports, allowing CFCs to be imported under HCFC labels;
- smuggling;
- “banking” of CFCs and selling after the phase-out date.

**European “Second Sulphur Protocol”**

The 1994 Oslo Protocol is one of the protocols to the 1979 Convention on Long-range Transboundary Air Pollution organised by the United Nations Economic Commission for Europe (UNECE). The 1985 Helsinki Protocol (First Protocol) under this convention imposed a uniform percentage target for all Parties to reduce $SO_2$ emissions by 30 per cent from the 1980 base year level by 1993. All Parties reached this target reduction level, although some view this as due largely to the opening up of eastern European (EITs) markets. The 1994 Oslo Protocol, which is known as the Second Sulphur Protocol, aims to reduce $SO_2$ emissions below “critical loads” (i.e. the amount of acidic deposition which can fall on a given area before harmful environmental impacts occur). A sulphur emission limit is set for each Party based on the “critical load” concept. Relationships between emissions and acidic depositions are calculated and compared with agreed critical loads for each country.

The Second Sulphur Protocol contains “enabling” language to allow two or more parties to jointly fulfil their obligations, subject to certain constraints that are to be specified to ensure that the overall environmental objectives are met and that the calculated environmental improvements for third parties are not compromised.[63] The enabling language in the protocol makes it possible for Parties to meet their commitments jointly by pooling their emission limits and for one Party to help another to reduce sulphur emissions if such reductions are cheaper in one country than another. The language explicitly states that trading could take place only between Parties to the Protocol, and each Party to the Protocol has an initial emission limit. It has been estimated that $SO_2$ emission trading could result in enormous cost savings (e.g. Klaassen, p. 210).

Several countries have begun to experiment with market instruments domestically, and some have instituted “bubble” concepts for domestic $SO_2$ emissions, allowing firms to offset increased emissions from one source by decreased emissions from another. Emission trading among governments or emission sources in different countries has not taken place to date, however. The main barrier to emission trade under the Second Sulphur Protocol is that the Parties must agree on rules for trading to ensure that

[62] Brack D, 1996

[63] Second Sulphur Protocol, Article 2, paragraph 7; ref Klaassen, 1995, p. 204.

environmental objectives are met and that third parties are not adversely affected by trade in $SO_2$ emissions.

These rules are still under negotiation, but some likely rules are:[64]

- only Parties to the Protocol may enter into a joint implementation agreement;

- Parties must specify the part of its emission reduction obligation one Party will implement through reductions by another Party and the emission reduction the other party will undertake;

- an assessment of the deposition impact would have to be provided;

- the level of expected cost savings and the means of compensation would have to be provided.

The location of $SO_2$ emissions can greatly affect levels of acidic deposition and some areas may have less tolerance for acid deposition than others.[65] For this reason, it may not be possible to trade sulphur emissions on a one-to-one basis; a ton of $SO_2$ emitted from one location may have very different impacts than a ton of $SO_2$ emitted from another location. It has been argued that it would be possible (although complicated) to covert $SO_2$ emissions into a quantity that can be traded by using an $SO_2$ exchange rate defined according to a formula that reflects the spatial differences which characterise deposition. This is not a problem that would affect trading of greenhouse gases which do not have local impacts.

With the second sulphur protocol an "Implementation Committee" was established, as well as a set of procedures for review and compliance. This Committee, which consists of representatives from eight Parties, periodically reviews and evaluates information regarding Parties' compliance to the Second Sulphur Protocol and has a mandate to provide constructive solutions in cases of non-compliance.

64 Jackson, Tim and Peter Baily (1996)

65 Jackson, Tim and Peter Baily (1996)

## APPENDIX 2: ESTIMATING THE POTENTIAL FOR TRADING: AN OVERVIEW OF QUANTIFIED RESULTS FROM THE LITERATURE

### Taxes versus permits

Under full certainty on the marginal cost and benefit of reducing an externality, a price instrument (a tax applied to the externality) or a quantity instrument (a limit on the level of the externality) can lead to similar welfare improvements through the full internalisation of the externality. The intersection of the marginal cost and benefit curves indicate the optimal tax, and the corresponding optimal level of the externality for society. With both instruments, economic costs and benefits are borne by society, to the point where marginal cost and benefit are equal. In the context of climate change, both marginal cost (greenhouse gas abatement cost) and marginal benefit (through stabilisation of Earth's climate) curves cannot be estimated with full certainty, and the superiority of taxes or quantity instruments in terms of welfare improvement cannot be determined. The choice of a price versus a quantity instrument is determined by other considerations (e.g. a tax applies a uniform marginal cost of reduction to all covered sources, whereas a quantity instrument achieves a certain environmental outcome).

Tradeable permits are a quantity instrument: a constraint is allocated among all sources of the externality, with a right to trade permits on a market. The market, if operating efficiently through unrestrained supply and demand (e.g. no significant transactions cost) will assure that cheapest reduction options are exploited, so that the environmental constraint is achieved in a cost-efficient manner. In the textbook version of tradeable permits, trading sources each have full information about their marginal cost curve and respond accordingly to the market price, by selling (buying) greenhouse gas units if their marginal reduction cost is below (above) the market price.

### How emission trading is modelled

In global macro-economic models (e.g. ABARE, GREEN, Global 2100), tradeable permits systems are modelled as follows: each region is 'allocated' an emission limit, knows the marginal cost to achieve this constraint unilaterally (through a domestic carbon tax), obtains similar information from other regions through the greenhouse gas units market, and sells emission reductions if its marginal cost of reduction is below that of the rest of the world (or purchases reductions from the rest of the world otherwise). At equilibrium, all regions achieve the overall emission limit cost-efficiently through the equalisation of the marginal abatement cost. In these models, governments do not have to find out their marginal abatement cost; they simply pass on the market price (through a carbon tax) to all emission sources. That way, the international trading mechanism is used cost-effectively at the national level: all sources reduce their emissions according to the price signal. In the real world, this would correspond to an international trading scheme in which *all emission sources* were allowed to trade. It is not likely that such comprehensive international greenhouse gas trading will take place immediately, hence efficiency gains computed by these models should be somewhat qualified.

Another key assumption in these studies is that participants all trade simultaneously and know all price and quantity information. At early stages at least, and until a real liquid market emerges, trading is more likely to be in a more limited form with bi-lateral trades and imperfect information about prices and quantities traded by others. Looking at the United States so-called “bubble” system, Atkinson and Tietenberg (1991, p. 28) have found that bilateral and sequential trading “results in substantially smaller cost savings than would be expected from the more sophisticated, .... cost-effective trading process that analysts have historically presumed to exist.” If greenhouse gas trading is more of the bilateral and sequential type, which is likely at least in early stages, the efficiency gains won’t be as large as the macro-economic models predict.

Bearing these caveats in mind, this appendix offers a sample of analyses related to marginal cost estimates (which provide the basic rationale for greenhouse gas emission trading), and then considers modelling results. The modelling studies estimate the macro-economic implications of possible trading schemes, and show potential efficiency gains that can be achieved through trading. These studies deal with energy-related $CO_2$ emissions only.

**The basis for trading: differences in marginal cost of reduction**

It is known that countries would not face similar costs to reduce their energy-related $CO_2$ emissions to achieve a comparable reduction objective. Such differences in both marginal and total abatement cost stem from differences in the projected population growth, the rate and nature of economic growth, economic trade relations with other countries, the efficiency of the current energy technology stock, and the availability of alternative energy sources.

One way to compute the marginal cost of reduction is to work from a set of available technologies covering emission sources, their respective costs, and to determine what technologies have to be substituted to ‘business-as-usual’ technologies in order to achieve certain reductions. The cost of introducing the last technology to avoid emitting one additional ton of $CO_2$ is the marginal cost of reduction (in fact, it corresponds to the carbon tax that would have to be introduced to persuade a rational economic agent to invest in this technology). This is the approach taken by the ETSAP/Annex IV study, where business-as-usual scenarios are first determined, and technology data is gathered for individual countries, to reflect their own mitigation costs (Kram, 1993; IPCC, 1996).

For a 10 per cent reduction from 1990 levels in the year 2020, the ETSAP study finds that marginal costs range from less then $20 (for the Netherlands) to $500/t$CO_2$ (for Norway). In this example, Norway would greatly gain from purchasing additional reductions from the Netherlands instead of achieving reductions at home. Of course, these estimates are highly dependent on the technologies included in the data set, but the general result remains valid: for similar reduction objectives, domestic marginal costs of greenhouse gas reductions differ widely.

The UNEP Greenhouse Gas Abatement Costing Study also provides an illustration of the range of marginal reduction costs, looking at both OECD and non-OECD countries (UNEP, 1994; see also IPCC, 1996, Chapter 9, for regional cost estimates of non-energy measures such as forestry and agriculture).

**Efficiency gains: reduction in overall costs through international trading**

Model results, such as those illustrated below, show that emissions trading could significantly decrease the overall cost of meeting a quantified reduction objectives (efficiency gains), and could also reduce the differences in GDP costs among regions for a similar reduction objective.

Based on the detailed technology-based analyses mentioned above, it is possible to compute an overall financial gain (although with no account taken of macro-economic effects) from reducing emissions where it is cheapest to do so, compared with achieving reductions at home. Using the UNEP study together with other bottom-up national $CO_2$ reduction studies in Poland and United Kingdom, Jackson (1995) discusses the general claim for cost-effectiveness through some form of emission trading, based on case studies illustrating partnership between UK and Poland and between UK, Denmark and Poland. A key element in this study is the existence of a large cost-effective potential for reductions in all three countries. The table below provides results on savings that could be achieved to meet a Toronto target (-20 per cent from 1988/89 levels in the year 2005), with and without international co-operation.

**Table 1: $CO_2$ reduction and savings with and without partnership to meet the Toronto target in the year 2005 (Jackson, 1995).**

| Region | $CO_2$ reduction required - 20 per cent million tons | Cost savings without partnership US$million | Cost savings with partnership US$million | Additional savings from partnership per cent |
|---|---|---|---|---|
| **UK + Poland** | 376 | 2010 | 2160 | 7.4 per cent |
| **UK+Denmark+Poland** | 385 | 2390 | 2545 | 6.5 per cent |

These results imply that even with the existence of a large, and well-exploited domestic energy efficiency potential such as that shown in column 2, partnership (which could be achieved through emission trading) would still bring some economic benefits to the participating countries.

Most modelling studies looking at the economic effects of international greenhouse gas emissions trading have relied on global macro-economic models. Such models provide a coherent macro-economic setting, which is often lacking in most technology-based analyses. On the other hand, large macro-economic models rely on standard neo-classical production and utility functions which lack technological realism. They also assume that all markets operate efficiently (without market barriers or failures). The general approach taken in these studies is to compare the cost of meeting country-specific reduction objectives on a country-by-country basis, with the cost of using a trading mechanism to meet the same overall reduction objective.

The following table gives one illustration of reductions that different regions would choose to do domestically if they were given the ability to trade greenhouse gas units among themselves. The overall objective assumed is to reduce emissions by 20 per cent in the OECD. Under the marginal cost figures obtained with MEGABARE, Japan, Australia, New Zealand and to a lesser extent the US would reduce emissions by less than 20 per cent at home and purchase reductions from other regions (Canada and the European Union). It shows that countries may find it more cost-effective to rely on emissions trading to achieve their commitment than to adopt similar national targets.

**Table 2: Percentage change in emissions with a tradeable quota system in OECD countries, with an overall reduction of 20 per cent (Hanslow *et al.*, 1994).**

| Australia | Canada | European Union | Japan | New Zealand | United States |
|---|---|---|---|---|---|
| -11 per cent | -21 per cent | -24 per cent | -6 per cent | -18 per cent | - 19 per cent |

What would be the efficiency gains, and the costs incurred by respective regions, with and without trading? Or, how much would emissions trading help lowering the differences in overall economic cost among participating regions?

Global economic studies reviewed by the IPCC find that, for global emission reduction objectives corresponding to a 2 per cent reduction from the baseline, the economic cost may be lowered by 6 per cent to 50 per cent, the smaller figure corresponding to long-term scenarios, when most technologies are widely shared among all participants so that marginal reduction costs tend to move closer (see table 9.25, p.339, IPCC WG III, 1996).

The OECD Model Comparison Project (II) provides the same type of comparison for an Annex I-only strategy of greenhouse gas mitigation (Manne and Oliveira-Martins, 1994). The study looks at a stabilisation scenario at 1990 level in the year 2050 applied unilaterally with regional carbon taxes, then through tradeable quotas based on flat rate reduction in Annex I regions. The following table shows the cost of greenhouse gas stabilisation in terms of changes in gross domestic product from business-as-usual, without and with trading among the identified Annex I regions. These results are based on OECD's GREEN model (Burniaux, Nicoletti and Martins, 1992).

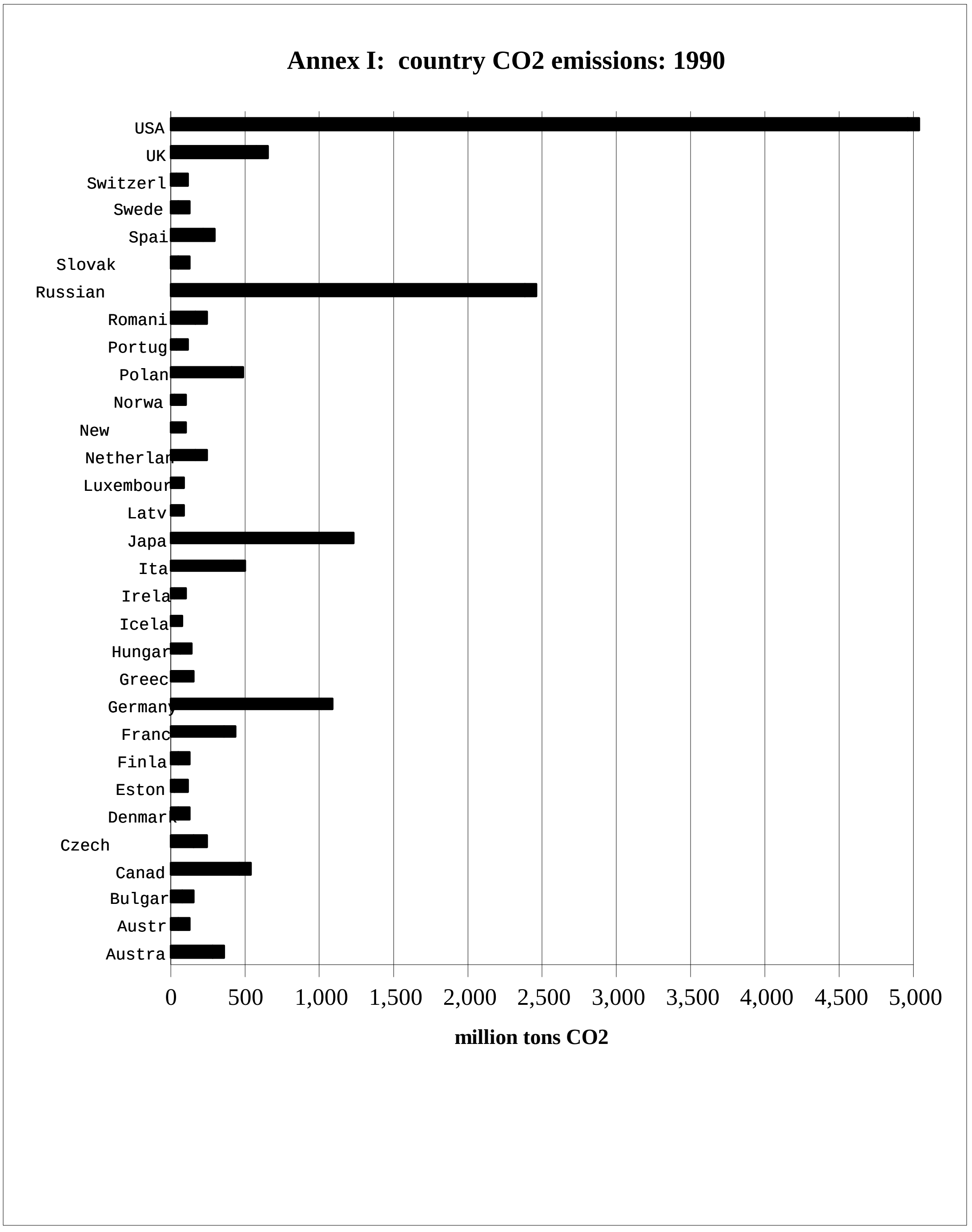
**Table 3: GDP cost for stabilisation of $CO_2$ emissions at 1990 level in 2030 and savings through emissions trading (Manne, Oliveira-Martins, 1994).**

| Region | GDP cost of unilateral stabilisation | GDP cost with emissions trading | Savings through emissions trading |
|---|---|---|---|
| Annex I | 0.8% | 0.4% | 50% |
| United States | 0.5% | 0.4% | 20% |
| Japan | 2.1% | 0.9% | 75% |
| EU (as of 1994) | 0.8% | 0.8% | 0 % |
| Other OECD | 0.5% | 0.4% | 20% |
| Former Soviet Union | 0.3% | -0.8% | Positive to negative |
| CEE | -0.6% | -1.3% | >100% |

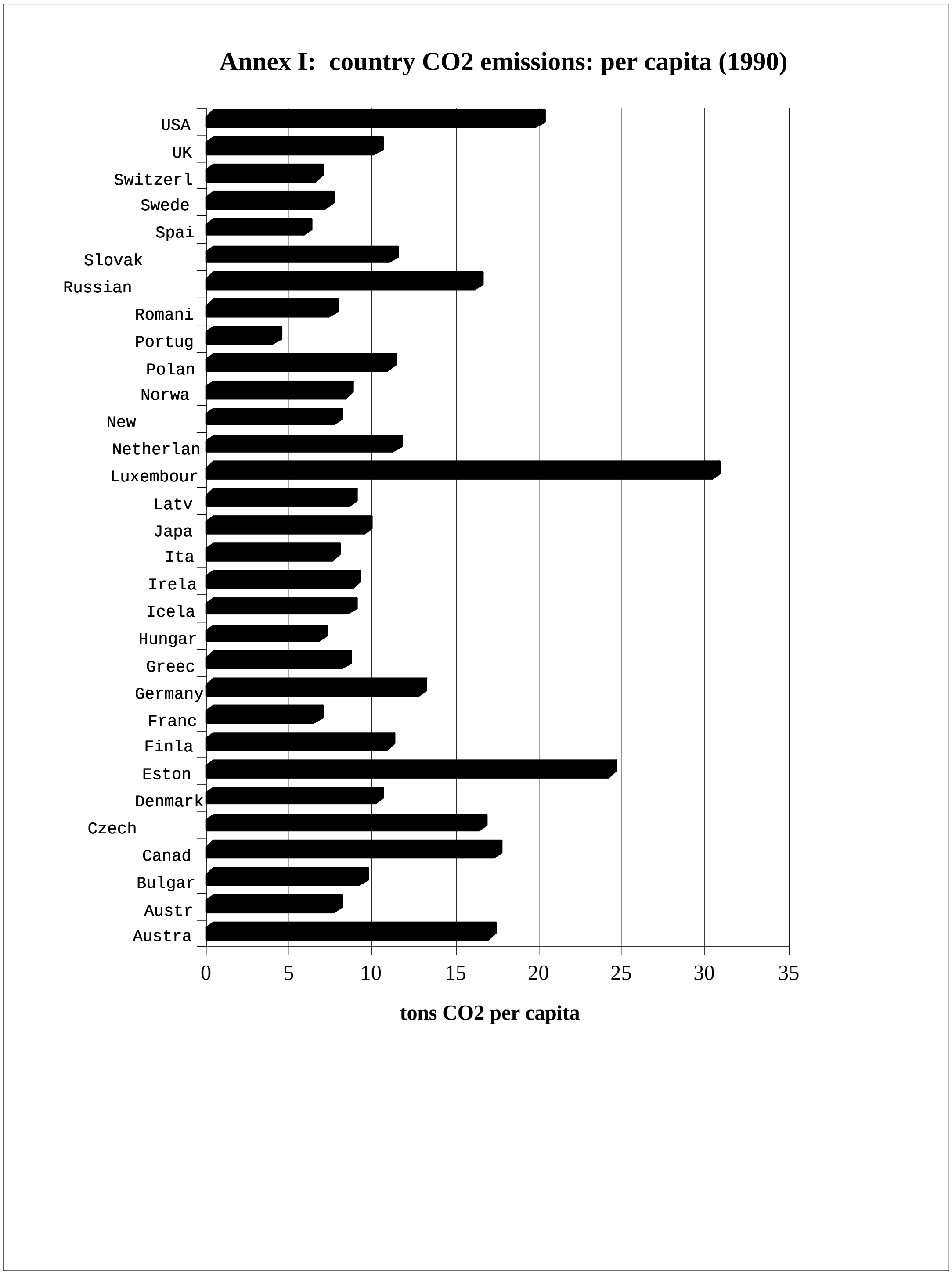
A wide range of results on efficiency gains from international greenhouse gas emission trading can be found in Chapter 9 of the IPCC Working Group III contribution to the Second Assessment Report (IPCC, 1996).

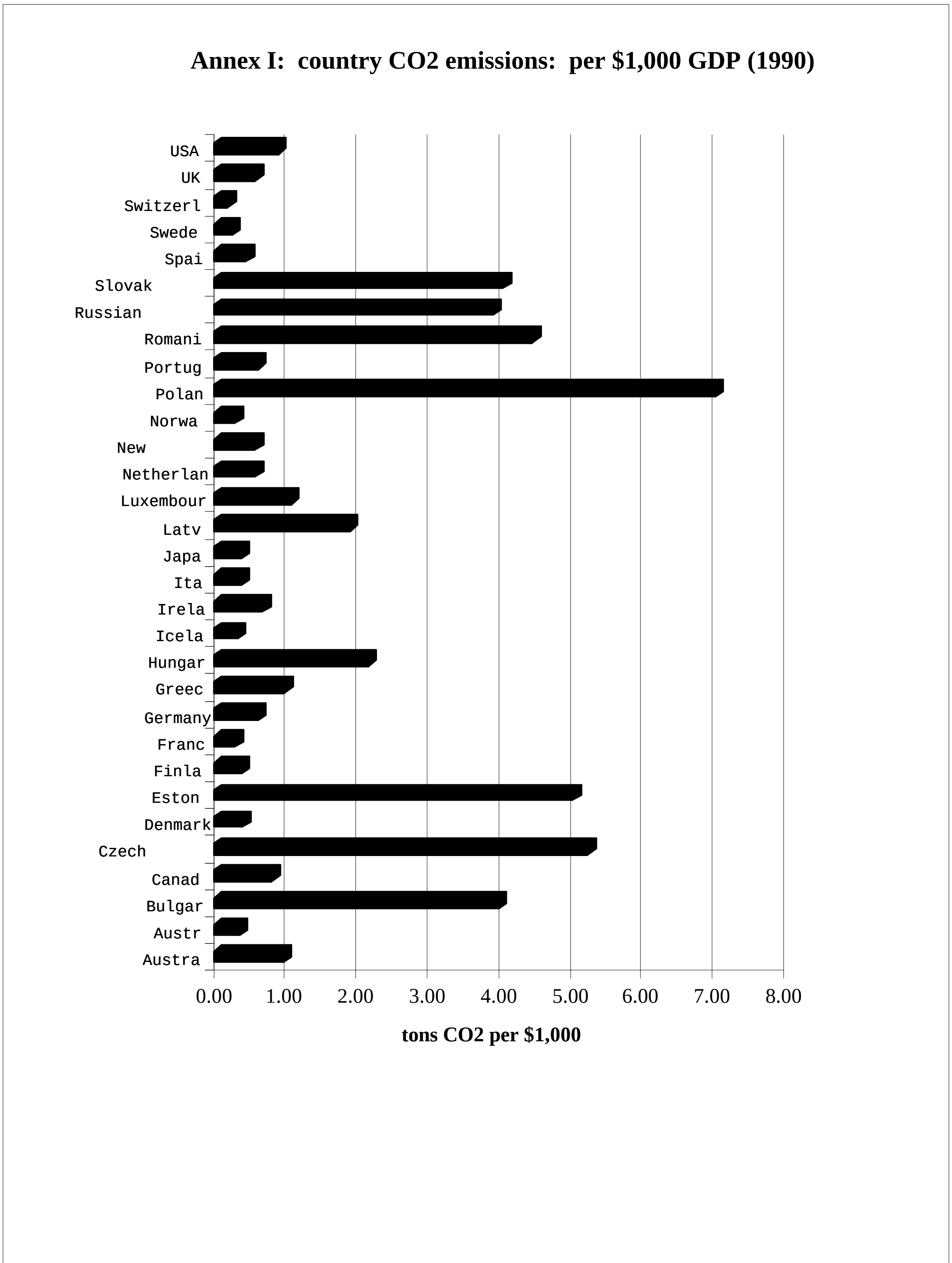
## APPENDIX 3: INITIAL ALLOCATIONS ILLUSTRATED

Certain indicators have been proposed to allocate efforts among Parties under the Berlin Mandate (GDP per capita, population, greenhouse gas and energy intensities, expected emission growth, expected marginal cost of reduction, etc. (see FCCC/AGBM/1996/7, FCCC/AGBM/1996/Misc.2/Add.2). Illustrations of different Annex I Party allocations (for $CO_2$ emissions only) are given here for flat rate $CO_2$ target at 1990 levels, 1990 levels of $CO_2$ per capita, and 1990 levels of $CO_2$ per unit GDP.



Annex I: country CO2 emissions: 1990
USA
UK
Switzerl
Swede
Spai
Slovak
Russian
Romani
Portug
Polan
Norwa
New
Netherlan
Luxembour
Latv
Japa
Ita
Irela
Icela
Hungar
Greec
Germany
Franc
Finla
Eston
Denmark
Czech
Canad
Bulgar
Austr
Austra
0
500
1,000
1,500
2,000
2,500
3,000
3,500
4,000
4,500
5,000
million tons CO2


Annex I: country CO2 emissions: per capita (1990)
USA
UK
Switzerl
Swede
Spai
Slovak
Russian
Romani
Portug
Polan
Norwa
New
Netherlan
Luxembour
Latv
Japa
Ita
Irela
Icela
Hungar
Greec
Germany
Franc
Finla
Eston
Denmark
Czech
Canad
Bulgar
Austr
Austra
0
5
10
15
20
25
30
35
tons CO2 per capita


Annex I: country CO2 emissions: per $1,000 GDP (1990)
USA
UK
Switzerl
Swede
Spai
Slovak
Russian
Romani
Portug
Polan
Norwa
New
Netherlan
Luxembour
Latv
Japa
Ita
Irela
Icela
Hungar
Greec
Germany
Franc
Finla
Eston
Denmark
Czech
Canad
Bulgar
Austr
Austra
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
tons CO2 per $1,000