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Policies, Measures, and Instruments

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EXECUTIVE SUMMARY

The purpose of this chapter is to examine the major types of policies and measures that can be used to mitigate net concentrations of greenhouse gases (GHGs) in the atmosphere.[1] Alternative policy instruments are described and assessed in terms of specific criteria, on the basis of the most recent literature. Naturally, emphasis is on the instruments mentioned in the Kyoto Protocol (the Kyoto mechanisms), because they focus on achieving GHG emissions limits, and the extent of their envisaged international application is unprecedented. In addition to economic dimensions, political, economic, legal, and institutional elements are considered insofar as they are relevant to the discussion of policies and measures.

Any individual country can choose from a large set of possible policies, measures, and instruments to limit domestic GHG emissions. These can be categorized into market-based instruments (which include taxes on emissions, carbon, and/or energy, tradable permits, subsidies, and deposit–refund systems), regulatory instruments (which include non-tradable permits, technology and performance standards, product bans, and direct government spending, including research and development investment) and voluntary agreements (VAs) of which some fall in the category of market-based instruments. Likewise, a group of countries that wants to limit its collective GHG emissions could agree to implement one, or a mix, of instruments. These are (in arbitrary order) tradable quotas, Joint Implementation (JI), the Clean Development Mechanism (CDM), harmonized taxes on emissions, carbon, and/or energy, an international tax on emissions, carbon, and/or energy, non-tradable quotas, international technology and product standards, VAs, and direct international transfers of financial resources and technology.

Possible criteria for the assessment of policy instruments include environmental effectiveness, cost effectiveness, distribution considerations, administrative and political feasibility, government revenues, wider economic effects, wider environmental effects, and effects on changes in attitudes, awareness, learning, innovation, technical progress, and dissemination of technology. Each government may apply different weights to various criteria when evaluating policy options for GHG mitigation, depending on national and sector-level circumstances. Moreover, a government may apply different sets of weights to the criteria when evaluating national (domestic) versus international policy instruments.

The economics literature on the choice of policies adopted emphasizes the importance of interest-group pressures, focusing on the demand for regulation. However, it has tended to neglect the "supply side" of the political equation, which is emphasized in the political science literature of the legislators and government and party officials who design and implement regulatory policy, and who ultimately decide which instruments or mix of instruments will be used. The point of compliance of alternative policy instruments, whether they are applied to fossil fuel users or manufacturers, for example, is likely to be politically crucial to the choice of policy instrument. And a key insight is that some forms of regulation actually benefit the regulated industry, for example, by limiting entry into the industry or by imposing higher costs on new entrants. A policy that imposes costs on industry as a whole might still be supported by firms who, as a consequence, would fare better than their competitors. Regulated firms, of course, are not the only group with a stake in regulation: opposing interest groups will fight for their own interests.

To develop reasonable assessments of the feasibility of implementing GHG mitigation policies in countries in the process of structural reform, it is important to understand this new policy context. Recent measures taken to liberalize energy markets were inspired mainly by desires to increase competition in energy and power markets, but they can have significant emissions implications also, through their impact on the production and technology pattern of energy and/or power supply. In the long run, the consumption pattern change might be more important than the sole implementation of climate change mitigation measures (e.g. see Chapter 2, the B1 scenario).

Market-based instruments–principally domestic taxes and domestic tradable permit systems–are attractive to governments in many cases because they are efficient; they are frequently introduced in concert with conventional regulatory measures. When implementing a domestic emissions tax, policymakers must consider the collection point, the tax base, the variation or uniformity among sectors, the association with trade, employment, revenue, and the exact form of the mechanism. Each of these can influence the appropriate design of a domestic emissions tax, and political or other concerns are likely to play a role also. For example, a tax levied on the energy content of fuels could be much more costly than a carbon tax for the equivalent emissions reduction, because an energy tax raises the price of all forms of energy, regardless of their contribution to carbon dioxide emissions. Yet, many nations may choose to use energy taxes for reasons other than cost-

[1] In keeping within the defined scope of Working Group III, policies and measures that can be used to reduce the costs of adaptation to climate change are not examined.

effectiveness, and much of the analysis in this chapter applies to energy taxes as well as to carbon taxes.

A country committed to a limit on its GHG emissions can also meet this limit by implementing a tradable permit system that directly or indirectly limits emissions of domestic sources. Like taxes, permit systems pose a number of design issues, including type of permit, sources included, point of compliance, and use of banking. To cover all sources with a single domestic permit regime is unlikely. The certainty provided by a tradable permit system that a given emission level for participating sources is achieved incurs the cost of uncertain permit prices (and hence compliance costs). To address this concern, a hybrid policy that caps compliance costs could be adopted, but the level of emissions would no longer be guaranteed.

For a variety of reasons, in most countries the management of GHG emissions will not be addressed with a single policy instrument, but with a portfolio of instruments. In addition to one or more market-based policies, a portfolio might include standards and other regulations, VAs, and information programmes:

- Energy-efficiency standards have reduced energy use in a growing number of countries. Standards may also help develop the administrative infrastructure needed to implement market-based policies. The main disadvantage of standards is that they can be inefficient, but efficiency can be improved if the standard focuses on the desired results and leaves as much flexibility as possible in the choice of how to achieve the results.
- VAs may take a variety of forms. Proponents of VAs point to low transaction costs and consensus elements, while sceptics emphasize the risk of free riding, and the risk that the private sector will not pursue real emissions reduction in the absence of monitoring and enforcement.
- Imperfect information is widely recognized as a key market failure that can have significant effects on improved energy efficiency, and hence emissions. Information instruments include environmental labelling, energy audits, and industrial reporting requirements, and information campaigns are marketing elements in many energy efficiency programmes.

A growing literature demonstrates theoretically, and with numerical simulation models, that the economics of addressing GHG reduction targets with domestic policy instruments depends strongly on the choice of those instruments. The interaction of abatement costs with the existing tax structure and, more generally, with existing factor prices is important. Policies that generate revenues can be coupled with policy measures that improve the efficiency of the tax structure.

Turning to international policies and measures, the Kyoto Protocol defines three international policy instruments, the so-called Kyoto mechanisms: international emissions trading (IET), JI, and CDM.[2] Each of these international policy instruments provides opportunities for Annex I Parties[3] to fulfil their commitments cost-effectively. IET essentially allows Annex I Parties to exchange part of their assigned amounts (AAs). IET implies that countries with high marginal abatement costs (MACs) may acquire emissions reductions from countries with low MACs. Similarly, JI allows Annex I Parties to exchange emissions reduction units among themselves on a project-by-project basis. Under the CDM, Annex I Parties receive Certified Emissions Reduction (CERs)–on a project-by-project basis–for reductions accomplished in non-Annex I countries.

Economic analyses indicate that the Kyoto mechanisms could reduce significantly the overall cost of meeting the Kyoto emissions limitation commitments. However, to achieve the potential cost savings requires the adoption of domestic policies that allow the use the mechanisms to meet their national emissions limitation obligations. If domestic policies limit the use of the Kyoto mechanisms, or international rules that govern the mechanisms limit their use, the cost savings may be reduced.

In the case of JI, host governments have incentives to ensure that emission reduction units are issued only for real emission reductions, assuming that they face strong penalties for non-compliance with national emissions limitation commitments. In the case of CDM, a process for independent certification of emission reductions is crucial, because host governments do not have emissions limitation commitments and hence may have less incentive to ensure that certified emission reductions are issued for real emission reductions only. The main difficulty in implementing project-based mechanisms, both JI and CDM, is to determine the net additional emissions reductions (or sink enhancement) achieved. Various other aspects of these Kyoto mechanisms await further decision making, including monitoring and verification procedures, financial additionality (assurance that CDM projects do not displace traditional development-assistance flows) and other additionalities, and possi-

[2] The ability of two or more Annex I Parties to form a "bubble" under Article 4 of the Kyoto Protocol is sometimes classified as one of the flexibility mechanisms as well. This mechanism allows a one time redistribution of the emissions limitation commitments among the participants. Since such a redistribution is strictly a political decision this mechanism is not discussed here.

[3] Annex I Parties to the UNFCCC (as amended by decision 4/CP.3) include all 39 Parties (38 countries plus the European Economic Community) listed in Annex B of the Protocol that will have quantified emissions limitation or reduction commitments for the 2008 to 2012 commitment period, plus Turkey and Belarus, which are Parties to the Convention but not listed in Annex B of the Protocol. To be precise, one should refer to the commitments of Annex I Parties listed in Annex B of the Kyoto Protocol. To avoid confusion, the term Annex I countries is used throughout this chapter to refer to Annex I Parties listed in Annex B of the Protocol; Turkey and Belarus are understood to be included within this umbrella term, but not within the group of countries that will have limitation commitments.

ble means of standardizing methodologies for project baselines.

The extent to which developing country (non-Annex I) Parties effectively implement their commitments under the United Nations Framework Convention on Climate Change (UNFCCC; referred to as the Convention in this chapter) may depend on the effective implementation by developed country Parties of their commitments under the Convention related to the transfer of financial resources and technology. The transfer of environmentally sound technologies from developed to developing countries is now seen as a major element of global strategies to achieve sustainable development and climate stabilization.

Any international or domestic policy instrument can be effective only if accompanied by adequate systems of monitoring and enforcement. There is a linkage between compliance enforcement and the amount of international co-operation that will actually be sustained. Many multilateral environmental agreements address the need to co-ordinate restrictions on conduct taken in compliance with the obligations they impose and the expanding legal regime under the World Trade Organization (WTO) and General Agreement on Tariff and Trade (GATT) umbrella. Neither the UNFCCC nor the Kyoto Protocol provides for specific trade measures in response to non-compliance. But several domestic policies and measures that might be developed and implemented in conjunction with the Kyoto Protocol could conflict with WTO provisions. International differences in environmental regulation may have trade implications also.

One of the main concerns in environmental agreements (including the UNFCCC and the Kyoto Protocol) is with reaching wider participation. The literature on international environmental agreements predicts that participation will be incomplete, and so further incentives may be needed to increase participation.

6.1 Introduction

6.1.1 *Introduction and Key Questions*

The main purpose of this chapter is to discuss the various policies and measures in relation to the different criteria that can be used to assess them, on the basis of the most recent literature. There is obviously a relatively heavy focus on the Kyoto instruments, because they focus on climate policy, have been agreed since the IPCC Second Assessment Report (SAR; IPCC, 1996, Section 11.5), and the extent of their envisaged international application is unprecedented. Wherever feasible, political economic, legal, and institutional elements are discussed insofar as they are relevant to the implementation of policies and measures. To make both theoretical and practical points the chapter offers occasional examples of policy instrument application, but the effort in this regard is limited by the existing literature, which is weighted towards the experience of industrialized countries.[4]

The chapter does not systematically discuss policies and measures typically used to encourage sector-specific technologies; such policies and measures are described in Chapters 3, 4, and 5. The emphasis is on the general description and assessment of policies and measures.

6.1.2 *Types of Policies, Measures, and Instruments*

A country can choose from a large set of policies, measures, and instruments to limit domestic greenhouse gas (GHG) emissions or enhance sequestration by sinks. These include (in arbitrary order): (1) taxes on emissions, carbon, and/or energy, (2) tradable permits[5], (3) subsidies[6], (4) deposit–refund systems, (5) voluntary agreements (VAs), (6) non-tradable permits, (7) technology and performance standards, (8) product bans, and (9) direct government spending and investment. Definitions of these instruments are provided in *Box 6.1*. The first four are often called market-based instruments, although some VAs also fall into this category.

A group of countries that want to limit their collective GHG emissions could agree to implement one, or a mix, of instruments. These are (in arbitrary order):

- tradable quotas;
- Joint Implementation (JI);
- the Clean Development Mechanism (CDM);
- harmonized taxes on emissions, carbon, and/or energy;
- an international tax on emissions, carbon, and/or energy;

Box 6.1. Definitions of Selected National Greenhouse Gas Abatement Policy Instruments

- An emissions tax is a levy imposed by a government on each unit of emissions by a source subject to the tax. Since virtually all of the carbon in fossil fuels ultimately is emitted as CO_2, a levy on the carbon content of fossil fuels–a carbon tax–is equivalent to an emissions tax for emissions caused by fossil fuel combustion. An energy tax–a levy on the energy content of fuels–reduces the demand for energy and so reduces CO_2 emissions through fossil fuel use.
- A tradable permit (cap-and-trade) system establishes a limit on aggregate emissions by specified sources, requires each source to hold permits equal to its actual emissions, and allows permits to be traded among sources. This is different from a credit system, in which credits are created when a source reduces its emissions below a baseline equal to an estimate of what they would have been in the absence of the emissions reduction action. A source subject to an emissions-limitation commitment can use credits to meet its obligation.
- A subsidy is a direct payment from the government to an entity, or a tax reduction to that entity, for implementing a practice the government wishes to encourage. GHG emissions can be reduced by lowering existing subsidies that in effect raise emissions, such as subsidies to fossil fuel use, or by providing subsidies for practices that reduce emissions or enhance sinks (e.g., for insulation of buildings or planting trees).
- A deposit–refund system combines a deposit or fee (tax) on a commodity with a refund or rebate (subsidy) for implementation of a specified action.
- A VA is an agreement between a government authority and one or more private parties, as well as a unilateral commitment that is recognized by the public authority, to achieve environmental objectives or to improve environmental performance beyond compliance.
- A non-tradable permit system establishes a limit on the GHG emissions of each regulated source. Each source must keep its actual emissions below its own limit; trading among sources is not permitted.
- A technology or performance standard establishes minimum requirements for products or processes to reduce GHG emissions associated with the manufacture or use of the products or processes.
- A product ban prohibits the use of a specified product in a particular application, such as hydrofluorocarbons (HFCs) in refrigeration systems, that gives rise to GHG emissions.
- Direct government spending and investment involves government expenditures on research and development (R&D) measures to lower GHG emissions or enhance GHG sinks.

[4] While an exhaustive review of in-country experiences with policy instruments is beyond the scope of this chapter, other recent works have focused on this issue (Panayotou, 1998; Huber *et al*., 1999; Speck, 1999; Stavins, 2000).

[5] What makes a tradable permit a market-based instrument is the possibility of trading the permit, not the initial allocation of the permits (unless such allocation is through auction). The SAR adopted the convention of using "permits" for domestic trading systems and "quotas" for international trading systems. This convention is followed throughout the chapter.

[6] Sometimes taxes are combined with subsidies, known as "fee/rebate".

Box 6.2. Definitions of Selected International Greenhouse Gas Abatement Policy Instruments

- A tradable quota system establishes national emissions limits for each participating country and requires each country to hold quota equal to its actual emissions. Governments, and possibly legal entities, of participating countries are allowed to trade quotas. Emissions trading under Article 17 of the Kyoto Protocol is a tradable quota system based on the assigned amounts (AAs) calculated from the emissions reduction and limitation commitments listed in Annex B of the Protocol.
- JI allows the government of, or entities from, a country with a GHG emissions limit to contribute to the implementation of a project to reduce emissions, or enhance sinks, in another country with a national commitment and to receive emission reduction units (ERUs) equal to part, or all, of the emissions reduction achieved. The ERUs can be used by the investor country or another Annex I party to help meet its national emissions limitation commitment. Article 6 of the Kyoto Protocol establishes JI among Parties with emissions reduction and limitation commitments listed in Annex B of the Protocol.
- The CDM allows the government of, or entities from, a country with a GHG emissions limit to contribute to the implementation of a project to reduce emissions, or possibly enhance sinks, in a country with no national commitment and to receive CERs equal to part, or all, of the emissions reductions achieved. Article 12 of the Kyoto Protocol establishes the CDM to contribute to sustainable development of the host country and to help Annex I Parties meet their emissions reduction and limitation commitments.
- A harmonized tax on emissions, carbon, and/or energy commits participating countries to impose a tax at a common rate on the same sources.[7] Each country can retain the tax revenue it collects.
- An international tax on emissions, carbon, and/or energy is a tax imposed on specified sources in participating countries by an international agency. The revenue is distributed or used as specified by participant countries or the international agency.
- Non-tradable quotas impose a limit on the national GHG emissions of each participating country to be attained exclusively through domestic actions.
- International product and/or technology standards establish minimum requirements for the affected products and/or technologies in countries in which they are adopted. The standards reduce GHG emissions associated with the manufacture or use of the products and/or application of the technology.
- An international VA is an agreement between two or more governments and one or more entities to limit GHG emissions or to implement measures that will have this effect.
- Direct international transfers of financial resources and technology involve transfers of financial resources from a national government to the government or legal entity in another country, directly or via an international agency, with the objective of stimulating GHG emissions reduction or sink enhancement actions in the recipient country.

- non-tradable quotas;
- international technology and product standards;
- international VAs; and
- direct international transfers of financial resources and technology.

Box 6.2 defines some of the instruments most prominently discussed in the literature. The first five are often called market-based instruments, although VAs can fall into this category also.

6.1.3 Policy Developments since the Second Assessment Report

In December 1997, Parties to the United Nations Framework Convention on Climate Change[8] negotiated the Kyoto Protocol (UNFCCC, 1997). The Protocol established, for the first time, legally binding quantified emissions limitation and reduction commitments that cover the emissions of six GHGs from a wide range of sources for the period 2008 to 2012 for 38 countries and the European Economic Community (EEC; Annex I Parties). These commitments represent a 5.2% reduction from the 1990 emissions of the Annex I Parties, and a 10% to 20% reduction from their projected emissions during the 2008 to 2012 period.

Annex I Parties can meet their commitments through measures to reduce domestic emissions, specified actions to enhance domestic sinks, and co-operative action with other Parties under Articles 4, 6, 12, or 17. Article 4 allows a group of Annex I Parties to agree to reallocate their collective emissions reduction commitment and to fulfil this commitment jointly. Such an arrangement is commonly referred to as a “bubble”. The members of the EEC are the only countries, to-date, to indicate that they are likely to establish one “bubble” to meet their commitments.

Article 6 defines JI for Annex I Parties, Article 12 establishes the CDM for projects in non-Annex I countries, and Article 17 allows emissions trading, a form of tradable quota, among Annex B Parties (see *Box 6.2*). The principles, modalities, rules, and guidelines for these three Kyoto Protocol mechanisms remain to be finalized. The Fourth Session of Conference of the Parties (CoP4) in Buenos Aires in November

[7] A harmonized tax does not necessarily require countries to impose a tax at the same rate, but to impose different rates across countries would not be cost-effective.

[8] That is, those countries that ratified the Convention, 186 countries as of September 2000.

1998 adopted a Plan of Action that includes development of these principles, modalities, rules, and guidelines for adoption at CoP6 at The Hague in November 2000.[9]

Annex I Parties have been implementing domestic policies to address their commitment under Article 4.2 of the Convention and evaluating possible policies to meet their more stringent commitments under the Protocol, taking into account the options afforded by the Kyoto mechanisms. Annex I Parties' national climate programmes are described in their National Communications, which are compiled by the UNFCCC Secretariat and subjected to external expert review under the Convention (UNFCCC, 1999, addenda 1-2).

Structural adjustment and energy sector reforms have been pursued in many countries. Although these are not GHG policies, they often have significant implications for GHG emissions, increasing or reducing emissions depending upon the circumstances (see Section 6.2).

6.1.4 Criteria for Policy Choice

Governments implement policies and measures to achieve particular objectives that they believe will not be achieved in the absence of government intervention, possibly because externalities or public goods are involved. Policies and measures can be generic, such as a general carbon tax or emissions trading, or sector-specific, such as a regulation applied to the construction sector, or a subsidy for green farming practices. The objective of this chapter is to assess different types of policies and measures, not to provide a complete list of these, so sector-specific policies and measures are discussed only in general terms.

Chapter 5 draws a distinction among five types of policy targets, each of which refers to a different interpretation (definition) of the concept of "barriers" to technological change: market potential, economic potential, socioeconomic potential, technological potential, and physical potential. Policies and measures can differ in the type of potential they aim to reach, but it is difficult to link specific policy instruments and specific potentials, because the potential achieved through virtually any policy instrument depends upon the "degree" to which that instrument is employed. For example, an emissions tax can be set at various levels; depending upon the level at which the emissions tax is set, it could have the effect (if perfectly implemented) of achieving any of the types of "potential" defined in Chapter 5.[10] For this, among other reasons, the prime focus in this section is on the possible criteria for policy instrument choice and evaluation.

Evaluation criteria are required both for the *ex-ante* choice of instruments and for the *ex-post* assessment of implementation and performance. Each government may apply different weights to the criteria when it evaluates GHG mitigation policy options.[11] Moreover, a government may apply different weights to the criteria when it evaluates national and international policy instruments, and the appropriateness of the criteria may vary depending on the degree of uncertainty about the pollution abatement cost and pollution damage functions. This general remark should be kept in mind when the various domestic and international policies, instruments, and measures discussed in this chapter are evaluated against the background of these criteria.

The criteria identified in SAR for the evaluation of policy options (Fischer *et al.*, 1998) are:

- Environmental effectiveness. How well does the policy achieve the environmental goal, such as a GHG emissions reduction target? How reliable is the instrument in achieving that target, does the instrument's effectiveness erode over time, and does the instrument create continual incentives to improve products or processes in ways that reduce emissions?
- Cost-effectiveness. Whether the policy achieves the environmental goal at the lowest cost, taking transaction, information, and enforcement costs into account.
- Distributional considerations. How the costs of achieving the environmental goal are distributed across groups within society, including future generations.
- Administrative and political feasibility. This includes considerations such as flexibility in the face of new

[9] The Plan of Action also includes work on the development and transfer of technologies, the financial mechanism, implementation of Articles 4.8 and 4.9 of UNFCCC, and preparations for the first session of the CoP serving as the meeting of the Parties to the Kyoto Protocol. This involves, *inter alia,* decisions on rules that govern sink enhancement activities under Articles 3.3 and 3.4 of the Kyoto Protocol.

[10] However, some concepts of "barriers" seem to imply combinations of instruments and levels or degrees of implementation. For example, if the problem is viewed as one of externalities, it is natural to use a tax on the relevant externality, with the tax set equal to the marginal social damages at the efficient level of control. On the other hand, although categories of "potential" refer to targets (ends), categories of policy instruments refer to the means of achieving those ends.

[11] The choice of weights is strongly influenced by many national and sector-level circumstances. These include government jurisdictional structure (e.g., sharing of government powers at various levels); geographical and climate profile (e.g., area size, regional weather patterns, heating degree days and temperature distribution, annual temperature variations, climate variability, latitude); economic setting (e.g., gross domestic product (GDP), GDP/capita, and GDP by sector); international trade patterns, such as percentage of energy-intensive exports; energy and natural resource base; demographics (e.g., population total and distribution, growth rate); land use and/or spatial patterns (e.g., distances driven/capita); industry and agriculture structure; building stock, and urban structure (e.g., home sizes); and environmental and/or health patterns (e.g., potential for highly variable climate change mitigation impacts across different national regions and urban areas).

knowledge, understandability to the general public, impacts on the competitiveness of different industries, and other government objectives (such as meeting fiscal targets and reducing emissions of pollutants).

The literature (e.g., OECD, 1997d) identifies some additional criteria, such as:

- Revenues raised in the case of market mechanisms, for instance, may constitute a second source of benefits from their use, over and above their direct environmental impact, depending on if and how the revenues are recycled.
- Wider economic effects include potential effects on variables such as inflation, competitiveness, employment, trade, and growth.
- Wider environmental effects, such as local air-quality improvement (usually referred to as the ancillary benefits).
- "Soft" effects, which relate to the impact of environmental policy instruments on changes in attitudes and awareness.
- Dynamic effects, which relate to the impact on learning, innovation, technical progress, and dissemination and transfer of technology.

The above lists of criteria guide the discussion of national and international policies and measures related to GHG abatement. However, the economics literature–particular theory development–focuses more on the cost-effectiveness criterion than on the other criteria mentioned, and there is a similar emphasis in this chapter, which is a review of the best available scientific literature. Wherever possible, literature on the potential equity impact of policies and measures is referred to. In addition, specific attention is paid to the political economy literature that describes policy choice (Section 6.1.5), the interactions of policy instruments with fiscal systems (Section 6.5.2), and the impacts on technological change (Section 6.5.3).

6.1.5 The Political Economy of National Instrument Choice

Some of the key lessons from the scholarly literature on political economy can be applied to instrument choice in climate policy at the national level. Since much of that scholarship focuses on policymaking in a limited set of developed nations, in particular in the USA, great care must be taken before applying any of these lessons to domestic politics generally.

6.1.5.1 Key Lessons from the Political Economy Literature

A useful starting-point is to view the policy process (at least in countries with strong legislatures) as analogous to a "political market" (Keohane *et al*., 1999). The demand side of such a "market" consists of the interest groups with a stake in the policy; in the environmental arena, such groups include regulated industries, producers of complementary products, environmental organizations, and (to a lesser extent) labour and consumer organizations. The supply side consists of the legislators and the administration involved in the design and implementation of the environmental policies and measures.

One key insight of this literature is that some forms of regulation can actually benefit the regulated industry, for example, by limiting entry into the industry or imposing higher costs on new entrants (Rasmusen and Zupan, 1991; Stigler, 1971). In the environmental arena, conventional regulation may provide firms with rents that result from reductions in output and raised prices as a consequence of regulation (Buchanan and Tullock, 1975; Maloney and McCormick, 1982). Stricter standards for new pollution sources benefit existing firms by raising barriers to entry (Nelson *et al*., 1993). Polluters' self-interest may also help explain the prevalence of tradable permits that have been allocated free ("grandfathered") when market-based instruments have been used. Permits allocated free to existing firms represent a transfer of rents from government to industry while auctioned permits and emissions taxes generally impose a heavier burden on polluters. Finally, VAs may be the preferred policy approach from industry's perspective, because these leave more of the initiative with the private sector (at least so it is perceived), which may enhance industry's chances of capturing rents.

Of course, it is important to recognize that industry may not act monolithically, since policies may have differential distributional impacts within a sector. A policy that imposes costs on industry as a whole might still be supported by firms that would fare better than their competitors. For example, firms that can achieve emissions reductions more cheaply may be more supportive of market-based schemes, such as tradable permits, than their higher-cost competitors (Kerr and Maré, 1997). In the realm of global environmental policy, the ban on ozone-depleting chlorofluorocarbons (CFCs) under the Montreal Protocol was, for instance, supported by those who expected to dominate the market for HFCs, then the leading substitute chemicals (Oye and Maxwell, 1995).

Regulated firms are not the only group with a stake in regulation; opposing interest groups will defend their own interests. Environmental groups, for example, tend to favour stringent targets, although many have opposed market-based instruments out of a philosophical concern that such policies give firms "licenses to pollute" or because of objections to attempts to quantify or monetize the environmental damages from pollution (Kelman, 1981; Hahn, 1989; Sandel, 1997). Some groups draw an ethical distinction between taxes and tradable permit systems, in which taxes are morally deficient because they put a price on emissions but set no upper limit on allowable pollution, while permits ensure a set level of emissions (Goodin, 1994). Other environmental groups support market-based policies in the hope that the resultant cost savings will make a higher level of environmental quality politically attainable, and possibly in part because of their own self-interest in distinguishing themselves from other environmental organizations (Svendsen, 1999). The US Clean Air Act defines permits as "limited authorizations to emit", to avoid limiting the ability to set lower emissions limits, which may also be a response to concerns of the environmental lobby that air should not become private property (Tietenberg, 1998). This indicates that the design of market-based instruments may be flexible enough to accommodate ethical concerns without undermining effectiveness.

While the political economy literature emphasizes the importance of preferences of interest groups, it has tended to neglect the "supply side" of the political equation: the legislators and government officials who ultimately design and implement regulatory policy. Government actors may have their own interests and preferences with respect to policy instruments:

- ideology or past experience may favour one instrument over another (Kneese and Schulze, 1975; Hahn and Stavins, 1991);
- legislators may prefer policies with (large but) hidden costs to those with (small but) visible ones (McCubbins and Sullivan, 1984; Hahn, 1987); and
- legislators responsible to local districts may emphasize distributional concerns over efficiency (Shepsle and Weingast, 1984).

Finally, the environmental administration may prefer direct regulation over market-based instruments, not only insofar as they are more familiar with it, but also because it gives them more control, and usually requires a relatively large administrative capacity.

These political factors, however, vary widely among countries. Whether or not a legislature exists, and if so whether in a parliamentary or presidential system, affects the support for particular policy instruments. Whether legislators are elected by district or by party list may affect the political support for different policy instruments as well. Factors such as the extent of interest-group organization and how groups interact with government are also critical–interest groups lobby legislators in some countries, sit on quasi-governmental decision-making bodies in others, are relegated to raising public awareness elsewhere, and in some countries are non-existent. Less tangible cultural and historical factors can also be critical in influencing the choice of instrument. For example, a country's experience with free markets generally may influence whether or not it chooses to use market-based policy instruments for environmental protection (Keohane, 1998). Finally, there are clear political economy limitations of individually applied price, non-price, and regulatory policies that often lead to the linked or combined policy strategy that is observed in practice.

6.1.5.2 *Implications for Global Climate Change Policy*

Since the political factors on the "supply side" are so heterogeneous across nations, the focus here is on the demand for regulations, building on the literature reviewed above to draw conclusions about the likely preferences and positions of key interest groups involved in climate change policy. Five groups seem particularly important: environmental organizations (especially in the USA and Europe), producers of carbon-based fuels (e.g., coal and oil producers), large users of fuel (e.g., electric utilities), manufacturers of energy-using products (e.g., automobile manufacturers), and manufacturers of energy-efficient and GHG-abatement technologies (e.g., manufacturers of efficient lighting). Environmental organizations in the USA and Europe seem to be divided–some groups have embraced market-based policies such as emissions permits and carbon taxes, while others object to such policies being applied without restrictions. Some also object to the option of so-called exchanges of "hot air" (national quota surpluses not created by active policies).

The range of industry sectors with large stakes in global climate policy suggests an important point: the various regulatory instruments that might be employed in climate change policy would each act at different levels of regulation, creating different points of compliance with very different implications for interest groups. Examples are:

- a system of tradable carbon permits (or a carbon tax, for that matter) imposed at the mine mouth, wellhead, or point-of-entry directly affects fuel producers (although the true economic incidence of the policy would be shared by downstream firms and consumers according to relative elasticities);
- a CO_2 tax, tradable emissions permit system, or emissions standard directly affects power plants; and
- energy-efficiency or fuel-efficiency standards directly affect manufacturers.

Industry groups–in particular, large producers and users of fuel–are also likely to focus their efforts on the allocation of carbon-reduction responsibilities, whatever the instrument. If a system of emissions standards is put into place, for example, existing firms will benefit if tighter standards are imposed on new sources, as has happened in a number of countries. Under an emissions tax, firms are likely to seek tax credits, differential tax rates, or exemptions to relieve their tax burden. In a system of tradable permits, firms are likely to support the free allocation of permits to participants, rather than to sell them at auction or distribute them to the public (for subsequent sale to firms). For project-based mechanisms–CDM and JI–they would favour leaving much of the initiative with the private sector (Jepma and Van der Gaast, 1999). Industries that stand to profit from GHG abatement, including renewable energy sources, are likely supporters of climate policies (Michaelowa and Dutschke, 1999a, 1999b).

From a political standpoint, the success of such efforts at the distribution of the burdens (or rents) is likely to depend on the political saliency of climate change policy. Taxpayers and organized "public-interest groups" are likely to oppose allocation schemes that benefit firms and/or benefit existing firms at the cost of the newcomers, thus reducing the scope for competition. If such groups wield clout, and if public interest in climate policy is high, then mechanisms that appear to benefit polluters at the expense of the public are less likely to be implemented.

In contrast, some environmental organizations have not opposed the allocation of rents to industry, recognizing that free allocation of permits may be the most likely path to implementing emissions reduction in some countries. Such concessions on allocation of rents to the industry have allowed these groups to secure other goals in return, such as continuous emissions monitoring–the US Acid Rain Program is a good example (Kete, 1992; Svendsen, 1999). In summary, allocation schemes favourable to industry appear likely in practice, because the question of distribution is central to industry, including industries that will profit from climate policy, but it is only of secondary importance to environmental groups that do not support free allocation and to other groups that seek to reduce GHG emissions. In the US Acid Rain Program, for example, sulphur dioxide (SO_2) emissions allowances worth about US$5 billion per year were allocated free to electric utilities, in part because of interest group politics (Joskow and Schmalensee, 1988).

Although the "supply side" is heterogeneous across nations, it is likely that some governments will favour policies that raise revenue while others will be more concerned with the distribution of costs across sources, regardless of the revenue implications.

6.2 National Policies, Measures, and Instruments

Before policies and measures that aim to reduce, or remove barriers that hamper, GHG emissions or enhance sequestration by sinks are analyzed, it is necessary to understand the substantial impact that other policies (such as the structural reforms of trade liberalization and liberalization of energy markets) have had on GHG emissions in several developing countries, economies in transition (EITs), and some developed countries. These policies, sometimes coupled with macroeconomic, market-oriented reforms, set the framework in which more specific climate policies would be implemented. Therefore, to assess correctly the feasibility of any particular policy, it is important to understand this new policy context. The effect of these reforms on energy use and GHG emissions is not clear *a priori*. Impacts can differ widely among countries, depending on implementation strategies and the existence of other regulatory policies designed to prevent the undesired effects of free market operation in the presence of externalities, information, and co-ordination problems.

6.2.1 Non-Climate Policies with Impacts on Greenhouse Gas Emissions

6.2.1.1 Structural Reform Policies

During the 1990s, several countries, especially EITs and developing countries, implemented drastic market-oriented reforms that have had important effects on energy use and energy efficiency, and therefore on GHG emissions.[12] Most countries have undergone what has been called the first generation of structural reforms: trade liberalization, financial deregulation, tax reform, privatization of state-owned enterprises, and opening the capital account as part of a strategy to attract foreign investment. Some countries have also implemented macroeconomic stabilization packages that include fiscal discipline, independence of monetary policy from the public sector, and exchange rate unification.

The two largest countries in terms of population and coal reserves, China and India, have also started to reform their economic systems towards a more free-market orientation, although at a slower pace than many other countries. Since 1978, energy use in China has increased, on average, 4%/yr. However, the energy–output ratio in China fell 55% between 1978 and 1995.[13] Garbaccio *et al*. (1999), using input–output tables, found that most of this reduction arose from technical change, a result supported by other studies (Polenske and Lin, 1993; Sinton and Levine, 1994). An increase in energy-intensive imports has also led to decreased energy use per unit of GDP. Others have attributed the reduction to sectoral shifts in the composition of output (Smil, 1990; Kambara, 1992). As reform-induced changes aimed at increasing GDP may increase the use of energy, the net effect on GHG emissions of structural reform in China is an empirical problem that depends on the choice of development strategies, technologies, and complementary policies.

Future economic growth in all countries may be accompanied by increases in GHG emissions. Even if economic growth increases energy efficiency (both in terms of production and consumption), the scale effect may dominate and GHG emissions may rise, depending on the extent to which other policies and measures are implemented to curb emissions (Fisher-Vanden, 1999).

[12] For a description of the main reforms implemented in Latin America see Lora (1997) and for EITs see Chandler (2000).

[13] Energy-output ratios discussed here require a caveat about China's GDP statistics. China's energy consumption in 1997 and 1998 decreased 0.6% and 1.6%, respectively, and its energy intensity drastically declined 80% from 1985 to 1998. Many analysts consider statistics on Chinese GDP to be speculative (IEA, 1998b).

6.2.1.2 Price and Subsidy Policies

Price signals can only influence demand and supply if they actually reach economic agents and if those economic agents have the opportunity to respond to them. In Russia, energy intensity increased by 30% between 1990 and 1998, while energy prices also increased tremendously (IEA, 1997b, p. 50).[14] Experience shows that it takes time for economic agents to adjust their behaviour to new price signals, not only because of capital stock turnover, but also because consumers often do not have an accurate knowledge of their energy consumption, or the technical capacity to reduce it. Various types of energy market reforms and the pace of energy price reforms are designed to create and clear channels for market signals to work.

It is a difficult policy challenge, and therefore a time-consuming process, to bring prices into line with real costs. This is true both in developing countries, where the poor pay a high cost for low-quality energy services (or a low cost that is heavily subsidized) and in developed countries. Although data on energy subsidies are incomplete, partly because such support is difficult to identify and measure, some evidence indicates that subsidies on coal production, including transfers from both consumers and taxpayers, are declining in a number of OECD and developing countries. Recent data suggest that the total producer subsidy estimates for the coal production of Germany, UK, Spain, Belgium, and Japan, which amounted to over US$13 billion at the beginning of the 1990s, had declined to less than US$7 billion by 1996 (OECD, 1998a, 1998b). In addition, case studies in the energy supply sector identified the following areas for potential subsidy reforms: removal of coal-producer grants and price supports; reforming subsidies to investment in the energy supply industry; and regulatory reform to eliminate non-tariff barriers to the energy trade (OECD, 1997a, 1997b).

An IEA (1999b) analysis of fossil energy subsidies in China, Russia, India, Indonesia, Iran, South Africa, Venezuela, and Kazakhstan–which accounted for 27.5% of the world's total energy demand in 1997–claimed that removing such subsidies would lower CO_2 emissions by 16% in these countries, amounting to a 4.6% reduction in global emissions.[15]

The transport sector–to give an important example–is another sector that receives subsidies detrimental to the environment. Transport is indirectly subsidized through infrastructure financing and through tax benefits, which enhance the transport volume. According to Shelby *et al*. (1997), energy subsidies were higher than those to transportation for the OECD area. They also found for the USA that larger CO_2 savings could be achieved through reform of indirect rather than direct transport subsidies, such as free parking and supporting the highway infrastructure. Reform policies to internalize external the effects will, according to one study, probably lower sector-wide emissions by 10–15% (OECD, 1997c).[16] These findings are in line with the results from other work on internalizing the external cost of transportation (ECMT, 1998). The same studies also indicate that local communities can better carry out policy reform in the transport sector, because transport subsidies may originate at the local level and local communities are more likely to value other ancillary benefits through policy reform (OECD, 1997c; ECMT, 1998). The transport sector is only mentioned as an example, because it is responsible for a large share of the national emissions in many countries.[17]

6.2.1.3 Liberalization and Restructuring of Energy Markets

Liberalization of energy markets gives the suppliers greater freedom in the extraction, processing, generation, transportation, and distribution or supply of energy products and the consumers greater freedom to choose from different providers (WEC, 1998). In the electricity subsector, the separation of transmission from generation followed the realization that only transmission is a natural monopoly (Hunt and Shuttleworth, 1996). Recently, various measures have been taken to liberalize energy markets. The EU, for instance, adopted rules to liberalize its electricity market (IEA, 1997a), which became operational early in 1999 (although some EU countries, such as the UK, had started earlier). It is expected that this will be followed soon by rules regarding a liberalization of the natural

[14] The major reasons for such growth were: a shift from an energy-intensive industrial structure to an even more energy-intensive industrial structure through maintaining the competitive advantages of energy and raw materials production in parallel with a sharp reduction of production in less energy-intensive industries; reduced share of production-related energy consumption at the expense of heating, ventilation, and air conditioning (HVAC) related energy consumption; reduced GDP, industrial production, and industrial energy consumption with the background of a relatively stable energy consumption in the residential sector; lack of control and metering devices; non-payment problem, which appeared partly as a reaction to the sky-rocketing growth of energy prices; weak capital markets and high interest rates to attract capital for energy-efficiency improvement projects (see Bashmakov, 1998).

[15] The percentage reduction in energy consumption was calculated by adding the gross calorific value of the reductions of the different fuels under consideration and expressing the sum as a percentage of total primary energy supply (TPES). As the calculations in this study did not take into account the refinery sector (a 5% reduction in gasoline use can amount to a reduction in TPES of more than 5%), the number thus derived constitutes a lower bound to the true reductions in energy consumption. Some country experts strongly criticized the methodology and quantitative results of the study (Bashmakov, 2000).

[16] In this regard the time element could be crucial. In fact, during the time in which prices adjust, transport volumes may grow, but growth may be retarded. Additional research is needed to establish these findings.

[17] Other sectors, including electricity generation, mining, cement, agriculture, and forestry, can also involve significant GHG emissions but benefit from subsidies that increase emissions.

gas market.[18] In the USA, as a result of changes in policies at both federal and state levels, the generation and sales of electricity are being opened to competition. Liberalization of the energy markets in developing countries and EITs has, in many cases, been part of the macroeconomic restructuring in these countries. Both in Africa and Latin America, one of the main driving forces behind the reform of the power sector is to attract private capital to expand and improve the sector.

Although these policies are mainly inspired by the wish to increase competition in the energy and power markets, they can have, through their impact on the choice of production technology, significant emissions implications. Energy restructuring may include regulation of the transmission monopoly, environmental cost internalization, and system-benefit charges (SBCs; see *Boxes 6.6* and *6.7*). Several studies have examined the effects on GHG emissions of the restructuring of the electricity industry, but the issue is far from resolved. Indications are that the impacts can be either positive or negative (IEA, 1998b). The degrees of the environmental effects of liberalization of the electric utility industry are case specific and depend on pre-existing circumstances (e.g., fuel mix, vintage of plant, taxation schemes, and other factors). They also depend on such factors as national endowment of resources, the fuel mix, the vintage structure of generation capacity, scope for restructuring, and the size and speed of policy reform (OECD, 1999). In short, energy-sector structural reform cannot, in itself, guarantee a shift towards less carbon-intensive power generation.[19] On the whole, however, it may provide for a more economically driven behaviour that would be more responsive to price signals placed on GHG emissions.

Finally, the impacts of energy-sector structural reforms can be enhanced if appropriate additional policy measures are taken,[20] such as demand-side management (DSM). An example of the latter is the British Energy Savings Trust, which was set up 3 years after restructuring the UK energy markets, in 1992, to finance DSM programmes run by regional electric companies.

According to an IEA study (IEA, 1999a), in the UK energy sector the structural reforms in the electricity, coal, and gas supply sectors reduced the share of electricity generated from coal from 65% in 1990 to 35% in 1997. This resulted from closure of older coal-fired plants and the construction of combined cycle gas turbines. In countries where the electricity systems are largely based on non-fossil fuels, like Brazil, Norway, Sweden, and Switzerland, competition without environmental regulation may well lead to increased CO_2 emissions, as gas-fired power stations often will be the most economically attractive option for the development of new capacity.[21]

In Japan, after liberalization of the power-generation market several independent power producers entered it. However, around 85% of their fuels were coal and residual oil that, though inexpensive, emit more CO_2 per unit of power generated. With the liberalization of the retail market, adopted in 2000 for large power users, it is possible that the construction of an atomic power or liquefied natural gas (LNG) plant, both of which require a longer lead time and a huge investment, will become difficult. This may lead to adverse effects in terms of CO_2 emissions (Sagawa, 1998).

Several studies in the USA have tried to quantify the potential impacts of restructuring the electricity industry on GHG emissions (see Lee and Darani, 1995; Rosen *et al.*, 1995; US FERC, 1996; Palmer and Burtraw, 1997). The FERC study suggests that there would be no significant increase in total CO_2 and nitrogen oxides (NO_x) emissions. The other studies, however, suggest that the impact of a more open transmission grid on CO_2 and NO_x emissions could be substantial. A more recent study by the US Department of Energy's (DOE) Office of Policy found that the restructuring envisioned under the Comprehensive Electricity Competition Act (CECA) will lead to 145–220 megatonnes (Mt) less CO_2 emissions in 2010 than would have occurred in the absence of an explicit policy to reduce CO_2 emissions from the electricity sector (US DOE, 1999).[22]

There is a growth in literature that focuses on the impacts of liberalization and restructuring of energy markets on the key technologies of interest in the context of GHG reduction, such as energy efficiency, co-generation, and renewables.[23]

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[18] An EU Directive on Natural Gas was adopted by the European Council of Ministers in May 1998 after publication in mid-1998; member states will have 2 years to implement the Directive.

[19] While it led to reduced emissions in some countries, such as the UK (Fowlie, 1999), it had the opposite effect in others, such as Australia.

[20] Another example is how liberalization of energy markets can reduce mitigation costs, especially when permit trading is not allowed, insofar as, for instance, electricity trade makes it easier to fulfil mitigation commitments (see also Hauch, 1999).

[21] In this regard, in Sweden the increase in carbon intensity was more the result of the political choice to phase out some nuclear power plants than of a link to the creation of an exchange. More generally, it may well be that the long-term impact of the international power exchange between Norway and Sweden will be that gas-fired power plants are added to the Nordic electricity system, causing coal-fired generation to decline. For some general information on the relationship between market deregulation and national mitigation commitments, see also Baron and Hou (1998).

[22] The DOE study incorporated policy proposals such as increasing the renewable-energy portfolio standards (RPSs) and removing barriers to the use of combined heat and power technologies where they are economical. In response to calls from environmentalists to reduce the potential impacts of restructuring the electricity industry, some countries initiated specific policies aimed at increasing the role of renewable energy in the electricity generation mix (Mitchell, 1995b, 1997; Wolsink, 1996; Wiser, 1997, 1999; Wiser and Pickle, 1997; Novem, 1998; Haddad and Jefferis, 1999; Wiser *et al.*, 1999).

6.2.2 Climate and Other Environmental Policies

Section 6.2.1 sets the general policy context in which any environmental policy will operate. This section focuses on specific policies to address climate change. The various policy instruments are assessed generically. In other words, there is not a sector-specific focus, because it is beyond the scope of this chapter. This may create some bias insofar as most sector-specific policies are technology oriented and of the command-and-control type.

6.2.2.1 Regulatory Standards

Regulatory environmental standards set either technology standards or performance standards, enforceable through fines and other penalties[24] (voluntary standards are discussed in Section 6.2.2.4). They may attach to a product, a line of products (e.g., US Corporate Average Fuel Economy (CAFE) standards), or the provision of a service (e.g., Japan requires that firms employ an energy manager).[25] In this chapter regulatory standards are distinguished from economic or market-based instruments (taxes and fees, permits, subsidies). Although all regulatory standards have consequences upon economic decision making, they differ from market-based instruments, which operate by directly changing relative prices rather than by specifying technology or performance outcomes.

Regulatory standards can be effective policies to address market failures and barriers associated with information, organization, and other transactions costs. They also are widely used to require actors to account for environmental externalities and, if continually modified to account for technical progress, they can provide dynamic innovation incentives (see Section 6.5.3). The principal sources of inefficiency associated with some regulatory standards derive from too narrow specifications of uniform behaviour in heterogeneous situations, weakness in controlling aggregate levels of pollution, and relatively more difficult application to products other than component or turnkey technologies. By requiring a certain level of performance without specifying how it should be achieved, performance standards generally reduce losses through inflexibility when compared to technology standards.

On the whole, energy efficiency standards have proved to be an effective energy conservation policy tool. Energy efficiency standards are widely used in over 50 nations and the number of standards is still growing.[26,27,28] For appliance standards enacted in the USA, cumulative energy savings in 1990 to 2010 are estimated at 24 etajoules (EJ), consumer life-cycle costs savings at US$46 billion, and emission reductions at about 400MtCO_2. For an early estimate, see McMahon (1992). The introduction of refrigerator and freezer standards in the EU is estimated to generate 300 TeraWatt hours (TWh) of cumulative electricity savings during 1995 to 2010 (Lebo and Szabo, 1996). Similar measures in Central and Eastern Europe are expected to save 60 TWh energy and to reduce emissions by 25 MtCO_2 (Bashmakov and Sorokina, 1996). In Japan, the law concerning the rational use of energy was strengthened on 1 April 1999 and is expected to reduce, in combination with the industries' voluntary actions plan, a maximum of 140 MtCO_2 in industry, transportation, and other sectors in total (Yamaguchi, 2000). Energy efficiency standards are especially effective in countries with high and growing appliance ownership and in countries in which consumers' energy awareness is low because of historically low energy prices.

The development of an effective regulatory standard requires national and, potentially, international, leadership to balance the interests of manufacturers, consumers, environmental non-government organizations (NGOs), and other interest groups, while creating sufficient societal support and incentives for successful implementation. While decisions to introduce regulatory standards are commonly made by legislatures, the development and implementation of standards over time is often left to a less transparent public administration. Although the enforcement and monitoring of all policy instruments is costly

[23] See Mitchell (1995b); Weinberg (1995); Boyle (1996); Lovins (1996); Nadel and Geller (1996); Owen (1996); Brown *et al.* (1998); Eyre (1998); Patterson (1999).

[24] There is no general agreement on terms by which regulatory standards are classified. In the USA, technology standards are often called command-and-control standards because they dictate particular technologies or best practices that limit the range of compliant behaviours. In other nations, command and control normally refers to all regulatory standards because they command behaviour and control compliance therewith.

[25] Mandatory standards are put in place by either specific legislation or government regulation. See, for instance, the Comprehensive National Energy Policy Act (USA, 1992), versus the Energy Conservation in Buildings Requirement for Thermal Performance and Heat–Water–Power Supply (Moscow City Government, 1999).

[26] In the USA in 1997 standards set for appliances are estimated to cover 75% and 84% of primary and delivered energy, respectively, in the residential sector. Similarly, it is estimated that standards covered 49% of both primary and delivered commercial energy use in 1997 (EIA, 1999).

[27] Technological progress provides a basis for regular updates of efficiency standards. In Russia, for instance, 1976 standards for refrigerators were improved by 50% in the 1980s and then in 1991 by an additional 50%. As a result, energy consumption of new units decreased by a factor of three (Bashmakov and Sorokina, 1996). The American Society of Heating, Refrigeration, and Air Conditioning Engineers updates its codes for residential and commercial buildings on average every 10 years.

[28] In France, successive building codes in the residential sector alone have generated 75% of the total energy savings over past 20 years. After building codes were set in 1974 they were made stricter in 1982, 1988, and 1998 (IEA, 1996, p.38).

and subject to failures, including discriminatory treatment and corruption, social science literature that examines the implementation of regulatory standards is more extensive.

Recent literature indicates that regulatory standards often precede market-based instruments and build institutional capacity in policy evaluation, monitoring, and enforcement (Legro *et al*., 1999). This is especially true in developing countries that lack both trained personnel and the financial resources to implement market-based instruments.[29] Technology standards have provided the initial training ground for public officials unfamiliar with any approach to environmental regulation. Russell and Powell (1996) found that developing countries with a better institutional capacity developed through experience with regulatory standards generally are more successful in implementing market-based environmental policies than less well-equipped countries. Cole and Grossman (1998) suggest that when historical, technological, and institutional contexts are taken into account, technology standards are efficient in the initial stages of environmental policy development.

The use of regulatory standards to force the internalization of environmental costs has initial distributional consequences different from those of environmental taxes or subsidies.[30] Regulatory standards reduce economic benefits previously shared by consumers, capital, and labour only to the extent of compliance costs and/or output foregone. Unlike environmental taxes or auctioned permits, regulatory standards do not extract the value of environmental costs on inframarginal production that continues after the policy is mandated.

Regulatory standards may also be used to correct barriers that arise from information failures and can yield net benefits to society if the costs associated with the regulation are less than the losses due to informational barriers.

6.2.2.2 Emissions Taxes and Charges

An emission tax on GHG emissions requires domestic emitters to pay a fixed fee, or tax, for every tonne of CO_{2eq} of GHG released into the atmosphere. Such a fee would encourage reductions in GHG emissions in response to the increased price associated with those emissions. In particular, measures to reduce emissions that are less expensive than paying the tax would be undertaken. Since every emitter faces a uniform tax on emissions per tonne of CO_{2eq} (if energy, equipment, and product markets are perfectly competitive) this would result in the least expensive reductions throughout the economy being undertaken first (IPCC, 1996, Section 11.5.1; Baumol and Oates, 1988). In the real world, markets, especially energy markets, deviate from this ideal, so an emissions tax may not maximize economic efficiency. Rather, the efficiency of an emissions tax should be compared with that of alternative policy measures. Criteria other than efficiency, such as distributional impacts, are likely to influence the design of the emissions tax where this is the chosen policy. Although equity considerations could be, in theory, better addressed through other redistribution mechanisms, in practice most energy and emissions taxes apply differential tax rates to different sources.

An emissions tax, unlike emissions trading, does not guarantee a particular level of emissions. Therefore, it may be necessary to adjust the tax level to meet an internationally agreed emissions commitment (depending on the structure of the international agreement; see Section 6.3). The main economic advantage of an emissions tax is that it limits the cost of the reduction programme by allowing emissions to rise if costs are unexpectedly high (IPCC, 1996, Section 11.2.3.1; see also Section 6.3.4.2).

An emissions tax needs to be adjusted for changes in external circumstances, like inflation, technological progress, and increases in emissions (Tietenberg, 2000). Inflation increases abatement costs, so to achieve a target emission reduction the tax rate needs to be adjusted for inflation. Fixed emissions charges in the transition economies of Eastern Europe, for example, have been significantly eroded by the high inflation (Bluffstone and Larson, 1997). Technological change generally has the opposite effect, reducing the cost of making emissions reductions. Thus, technological change generally increases the emissions reductions achieved by a fixed (real) tax rate. New sources increase emissions. If the tax is intended to achieve a given emissions limit, the tax rate will need to be increased to offset the impact of new sources (Tietenberg, 2000).

Implementation of a domestic emissions tax touches on many issues (Baron, 1996). Policymakers must consider the collection point, the tax base, the variation or uniformity among sectors, the association with trade, employment, revenue, or R&D policies, and the exact form of the mechanism (e.g., an emissions tax alone or in conjunction with other policy measures). Each of these can influence the appropriate design of a domestic emissions tax.

6.2.2.2.1 Collection Point and Tax Base

Since GHG emissions caused by the combustion of fossil fuels are closely related to the carbon content of the respective fuels, a tax on these emissions can be levied by taxing the carbon content of fossil fuels at any point in the product cycle of the

[29] This also applies to current climate policy. Under certain circumstances it is preferable to adopt a more intensive regulatory standards phase by financing capacity building and hands-on-experience in the flexible instruments for administrators in developing countries (Montero, 2000c). The Activities Implemented Jointly (AIJ) pilot phase might be considered a step in this direction.

[30] Regulatory standards reverse the distributional effects of efficient subsidies in that the incremental costs of regulation are borne not by producers, but by the subsidy-financing tax base or those consumers who must cross-subsidize the environmental goods (see Section 6.2.2.6).

fuel (EIA, 1998).[31, 32, 33] A producer–importer tax on the carbon content of fossil fuels, coupled with a crediting scheme for exports and non-combustion end-uses, closely replicates the effect of a direct emissions tax on end-users (CCAP, 1998). Further, by focusing on producers and importers rather than end-users, the number of regulated entities is dramatically reduced. Fewer regulated entities lead to substantially lower monitoring and enforcement costs. Modelling studies show that taxing fossil fuels on a basis other than carbon content–for example, energy content or value–also reduces CO_2 emissions, but usually at a higher cost for a given emissions reduction target (IPCC, 1996, Section 11.5.1).[34]

6.2.2.2.2 Association with Trade, Employment, Revenue, and Research and Development Policies

In an open economy, countries are often concerned about the impact of emissions taxes on tradable goods sectors (OECD, 1996a; IPCC, 1996, Section 11.6.4). In practice, therefore, current carbon taxes generally tend to have a lower rate on the tradable goods sectors, especially when they are energy intensive. When some trading partners do not undertake emissions reductions, for example, domestic emissions taxes on carbon-intensive tradable goods might simply shift production to countries without such taxes. One solution is corrective taxes on imports and exports (OECD, 1997d). If this option is not available (see Section 6.4.2), an emissions tax that is differentiated among various sectors in the economy may be preferred (Hoel, 1996). Another solution, which Böhringer and Rutherford (1997) find to be more efficient, is sector-specific wage subsidies to protect jobs in the carbon-intensive tradable goods sector.

Opposition to increased environmental regulation in general often centres on concerns that firms might relocate and/or people might lose their jobs (Rosewicz, 1990).[35] Emissions taxes are particularly vulnerable to this criticism since they require firms not only to pay abatement costs, but also taxes on their unabated emissions (Vollebergh *et al.*, 1997). Several recent papers, however, argue that emissions taxes are more cost-effective than direct regulation and may even lead to higher employment (Wellisch, 1995; Hoel, 1998). The intuition is that the right to emit pollution constitutes a rent. With mobile capital markets, part of that rent accrues (inefficiently) to owners of capital unless it is taxed (Schneider, 1998). By using the tax revenue to offset labour taxes, employment can be higher than in similarly designed policies using direct (technology) regulation (Hoel, 1998; see also Section 6.5.1). Chapters 8 and 9 refer to various sources corroborating the evidence that using emissions and/or energy taxes to reduce distortionary labour taxes tends to increase employment.

Even with an efficient outcome, the immediate profit losses to firms under an emissions tax might be considered "unfair" to firms in carbon-intensive industries. In that case, a portion of the tax revenue can be returned to firms (lump sum) to compensate them for lost profit without a loss of efficiency. Bovenberg and Goulder (1999) estimate that only 15% of the revenue from an emissions tax would need to be refunded to industry to maintain existing profit.

In addition to reducing emissions and raising revenue, a carbon tax also influences innovation. This occurs alongside any distinct R&D policies that are undertaken (see also Section 6.2.2.6). Early work in this area indicated that auctioned permits would provide the largest incentive to innovate, followed by emissions taxes and then permits allocated free (Milliman and Prince, 1989). More recent work demonstrates that with a large number of competitive firms and imperfect R&D markets, taxes may induce more innovation than auctioned permits, although the welfare effects remain ambiguous (Fischer *et al.*, 1998). The incentive for innovation is therefore a necessary design consideration (Grubb *et al.,* 1995; see Section 6.2.2.6). It has been suggested in this regard that the targetted recycling of emissions taxes that support renewable energy and energy efficiency activities may offer specific benefits (see Sections 6.2.2.6, 6.5.1, 6.5.2; IPCC, 1996).

In practice, both energy and carbon taxes have already been adopted as responses to commitments under the UNFCCC. The European Commission (EC), for instance, has issued several tax proposals designed to reduce emissions of CO_2 from fossil fuel use. For example, Finland, Netherlands, Denmark,

[31] Empirical work suggests that to focus on all six gases of the Kyoto Protocol (CO_2, CH_4, N_2O, SF_6, PFCs, HFCs) and not just the carbon content of fuels reduces compliance costs substantially (Reilly *et al.*, 1999).

[32] This assumes that "carbon removal and disposal" strategies (e.g., removing CO_2 from stack gases and sequestering them in geological formations or land use change involving afforestation and reforestation) receive payments equivalent to the tax rate per tonne CO_{2eq} sequestered. It also assumes that non-energy GHG emissions are also subject to the tax or to policies for which the marginal abatement cost is equal to the tax rate.

[33] One aspect that is also relevant is taxing net emissions versus gross emissions. Land use changes are included in the Kyoto Protocol. A national Computable General Equilibrium (CGE) model in which emissions from the use of timber and carbon accumulation in the forest are taken into account, thus calculating net emissions, is given by Pohjola (1999). If net emissions are taxed, Pohjola (1999) finds that the carbon tax needed to reduce net emissions by the same amount as emissions from fossil fuels is significantly lower.

[34] Energy taxes may be more efficient than taxes on carbon alone if there are negative externalities unrelated to CO_2 associated with the energy services delivered.

[35] A 1997 OECD study (OECD, 1997d) suggests that the evidence that more stringent environmental regulation is reflected in the pattern of international trade in goods produced by traditionally polluting activities is not yet clear. This conclusion could change, however, if energy taxation or any comparable measure is introduced at a large scale.

Sweden, and Norway all have energy taxes based in part on carbon content (Speck, 1999; see Section 6.1.3). Other countries that have recently introduced carbon or energy taxes to help achieve their climate change commitments include Slovenia, UK, Italy, Germany, and Switzerland. France is also considering increasing energy taxes on industry for the same purpose. None of these countries have been able to introduce a uniform carbon tax for all fuels in all sectors, because unilateral nature policies raise. In most cases for which an energy or carbon tax is implemented, the tax is implemented in combination with various forms of exemptions (e.g., rebates, VAs).

6.2.2.3 Tradable Permits

A country committed to a limit on its GHG emissions can meet this limit by implementing a tradable permit system that directly or indirectly limits emissions of the domestic sources covered by the commitment. The large number and diverse nature of the sources covered by national limits on GHG emissions raises issues of how to assign permit liability. If permit liability is imposed at the point of release to the atmosphere, a so-called "downstream" system, individual vehicle owners and households would have to participate.

Some emissions, such as HFCs, sulphur hexafluoride (SF_6), and energy-related CO_2, can be controlled indirectly, with a so-called "upstream" system, by limiting substances that ultimately result in GHG emissions (see, e.g., IPCC, 1996; Bohm, 1999).[36] Since energy-related CO_2 emissions are linked to the carbon content of fossil fuels, the system could be implemented by requiring fossil fuel producers and importers to hold permits equal to the carbon content of the fuels sold domestically.[37] Permit liability for energy-related CO_2 emissions could be imposed at any point in the fossil fuel distribution chain and at different points for different categories of sources, for example downstream for large industrial sources and on petroleum companies for transportation fuels.[38] Industrial non-energy sources of GHG emissions also lend themselves, at least partially, to inclusion in a tradable permit system (Haites and Proestos, 2000).

Permits equal to the emissions limit are distributed (*gratis* or by auction, usually to permit-liable entities) and each permit-liable entity is required to hold permits equal to its actual GHG emissions or actual sales of regulated substances as appropriate. Permits may be traded, at least domestically and at least among permit-liable entities. Such a tradable permit system is well known from the literature to be cost-effective if transactions costs are not prohibitively high and if there are no significant imperfections in the permit market and other markets pertaining to the emitting activities (see IPCC, 1996, p. 417).[39]

Some sources of GHG emissions, such as methane emissions from livestock, as well as small sources, are very difficult to include in a tradable permit system because it is difficult to measure actual emissions (or an accurate proxy for actual emissions). In practice, then, the emissions cap for the tradable permit system is less than the national emissions limit and some sources need to be addressed by other policies.[40] For example, a government that takes part in an international agreement, such as the Kyoto Protocol, may establish an emissions cap for the tradable permit system on the basis of the initial national limit or the *ex post* limit, taking into account its net transfers under the Kyoto mechanisms.[41]

With a significant number of permit-liable entities it should be possible to establish market institutions that have low transac-

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[36] HFCs and SF_6 are manufactured gases used in a variety of applications and ultimately escape to the atmosphere. Limiting sales of these gases in the country effectively limits the subsequent emissions. Cost-effectiveness then requires that the prices of the regulated substances rise to reflect the social marginal cost of abatement (see Section 6.4.1), so that the sources have the correct incentive to implement the appropriate abatement measures.

[37] Virtually all of the carbon content of fossil fuels is converted to CO_2 upon combustion. Thus, if there are no commercially viable CO_2 capture and sequestration technologies, the CO_2 emissions are closely related to the carbon content of the fuel. If CO_2 capture and sequestration is implemented, an upstream system based on the carbon content of fossil fuels could still be implemented, but it should be complemented by a system of credits for sequestered CO_2. Some fossil fuel is used as a feedstock for products that sequester the carbon for a relatively long time. An upstream system should include provisions to exempt the carbon sequestered in such products. A particular aspect that can be introduced is to specify a validity period of permits by establishing gradual devaluation and an expiration date. By introducing this dynamic incentives could be created.

[38] See NRTEE (1999) for a comprehensive overview of options for the design of a domestic GHG tradable permit system. Remember that the liable point may differ from the point of allocation. See Matsuo (1999) and Iwahashi (1998) on this.

[39] Tradable permits have been used to implement a cap on SO_2 emissions by electricity generators in the USA and on NO_x and SO_x emissions by large sources in the greater Los Angeles area (the Regional Clean Air Incentives Market (RECLAIM) Programme; e.g., Schmalensee *et al*. (1998); Stavins (1998a)).

[40] NRTEE (1999) suggests that coverage for different designs can range from 30% to over 90% of total emissions. Given a satisfactory solution to the monitoring problems, cost-effectiveness is improved by including as large a share of total emissions as possible in the tradable permit system.

[41] The national government could choose to be a net buyer or seller using the Kyoto mechanisms. To achieve compliance, the cap for the domestic trading system should reflect the national limit after adjustment for these international transfers. Whether the domestic cap is based on the initial commitment (no government transfers under the mechanisms) or the *ex post* limit, permit-liable entities could be allowed to acquire quotas under the Kyoto mechanisms, if allowed by the rules governing those mechanisms, for use towards compliance with their obligations under a domestic tradable permit system.

tion costs and that limit the scope for market power.[42] The only situation in which there might not be enough permit-liable entities is in a small country with an oligopolistic market for fossil fuels and an "upstream" trading system.[43] In particular, if an exchange institution is used, transaction costs are likely to be small and market power (the possibility of one or more market parties to manipulate market conditions in their favour, or to try to achieve such a result by taking speculative positions) is unlikely to have a noticeable influence on the transaction volume or final market prices (e.g., Smith and Williams, 1982; Carlén, 1999).[44] If the domestic tradable-permit system is integrated with an IET market (see Section 6.3.1)–which further increases cost-effectiveness–any remaining market power concerns are greatly diminished.

Some analysts argue that to allow entities, in addition to permit-liable participants, to participate in the market is desirable for several reasons. It allows the risks of changes in permit prices to be borne by the entities (e.g., private brokerage firms, traders, professional speculators, or arbitrators) best able to bear those risks. It may also improve intertemporal efficiency if other entities have relevant information not heeded by permit-liable participants. The behaviour of participants in the permit market might need to be supervised in the same manner as in other financial markets, regardless of whether they are permit-liable or not, to prevent abuses such as insider trading and efforts to manipulate the market.

Permit prices fluctuate, but this does not mean that prices of the products of permit-liable entities fluctuate to the same extent. Crude oil prices change daily, but the prices of various petroleum products, such as gasoline, are much more stable. Forward contracts and options are used to transfer the risks of price fluctuations to sources willing and able to bear those risks.[45] The same mechanisms are likely to be used by permit-liable entities to deal with the risks of fluctuations in permit prices.

The market value of the permits needed by a permit-liable entity is passed on to customers in the form of higher prices, to employees through lower wages, to shareholders through lower returns, and to suppliers through lower prices. To answer how the costs are shifted to these different groups requires a comprehensive model of the economy with accurate values for relevant price elasticities. Ultimately, the costs are borne by individuals, with the impact on a particular person reflecting his or her role as an employee, investor, and/or consumer of various products.[46]

Permits can be distributed to permit-liable entities (and/or others) *gratis* or by auction.[47] *Gratis* allocation requires a rule for distributing the permits among the recipients. Since the permits represent an asset transferred to the recipients it can be difficult to find a rule that is considered fair by all. An auction raises revenue. All of the revenue could be returned to permit-liable entities, but this needs to be done in a manner that leaves them with an economic incentive to reduce their emissions. The revenue could also be used for a variety of other purposes. Compensation could be provided to industries, whether or not they are permit-liable entities, or households that bear a disproportionate share of the impact. The revenue could also be used to reduce existing distortionary taxes and so reduce the net cost of the emission reduction policy (see Section 6.5.1). The introduction of an emissions trading programme, like the imposition of any new tax or regulation, imposes adjustment costs on the affected entities. This is true whether the permits are auctioned or distributed *gratis*. Moreover, some *gratis* allocation rules discriminate against new entrants (IPCC, 1996; Cramton and Kerr, 1998; Zhang, 2000).

[42] The number of participants in the trading programme could be small if a country chooses to make fossil-fuel producers and importers permit-liable and there are very few such firms. This implies that the domestic market for fossil fuels is not competitive. If the country created a competitive market for fossil fuels, the number of permit-liable entities would likely be sufficiently large to create a competitive market for permits as well. Sweden, which imports all its fossil fuel, has some 350 fossil fuel importers that are now liable to a carbon tax and that would be permit-liable should it choose to shift to a tradable permit system.

[43] Even under such circumstances a competitive permit market could be created by restructuring the fossil fuel market.

[44] Although the US SO_2 allowances are not traded on an exchange, over 9.5 million allowances were transferred between economically unrelated parties in 1998 and brokerage commissions for a simple transaction are approximately 1% of the sale price.

[45] For crude oil and natural gas, the options are exchange-traded contracts. Such transactions also occur in the SO_2 allowance market; they do not require exchange-listed contracts.

[46] This is true regardless of the domestic policy adopted to meet the GHG emissions limit. However, the total cost of meeting the limit, and the distribution of that cost, may differ with the policy adopted (see Section 6.5.1).

[47] Auctioned permits are equivalent to a tax, if adjusted with a similar frequency, and are designed to achieve an equal emissions reduction by the same sources. If, instead, tradable permits are allocated *gratis* to certain entities, the same distribution is obtained as in the tax case if the tax revenue is redistributed to these entities in the amount of the wealth of the permits otherwise allocated to them (IPCC, 1996, p. 410). To redistribute the tax revenue it is necessary to confirm the total amount of permits allocated. This means that the taxation system in combination with the revenue redistribution inevitably involves a key dimension of the permit trading system, so that the advantage of the taxation system in administrative costs diminishes significantly. If the scale of allocation for the permits in *gratis* is determined on the basis of historical factors, the allocation in *gratis* does not reduce efficiency in emissions reduction. Tax exemption and reduction, however, may reduce or even eliminate incentives for emissions reduction and depreciate the efficiency factor embraced in the taxation policies, because the scale of reduction or exemption is determined by the current emissions quantities.

Assuming compliance, permits are a more certain means than taxes of achieving quantified national emission limits. In addition, a tradable permit system with auctioned permits is more likely to provide the efficient price signal than a tax rate set by the government. However, the certainty of achieving the emissions levels provided by a tradable permit system incurs the cost of permit prices being uncertain. Some have argued in favour of introducing a trigger price into a permit trading system to meet this concern, namely the absence of an upper bound on the price and hence on compliance costs (See e.g., Kopp *et al*., 1999a). When the permit price reaches the trigger, additional permits are sold by the government to prevent the price from rising further. Such a hybrid system fails to guarantee particular emissions levels, but does limit the economic cost of the programme for its users.[48]

6.2.2.4 Voluntary Agreements

No international definition of a VA is universally accepted (CEC, 1996; EEA, 1997; OECD, 1998a). VA is used here to mean an agreement between a government authority and one or more private parties, as well as a unilateral commitment that is recognized by the public authority, to achieve environmental objectives or to improve environmental performance beyond compliance.[49]

VAs may take a wide variety of different forms. The large-scale VAs in the field of GHG mitigation activities in Japan and the Netherlands are referred to in *Boxes 6.3* and *6.4*. For a description of the US "market transformation" type VA and the German VAs, see Mazurek (1998) and Storey *et al.* (1999), and Eichhammer and Jochem (1998), respectively. Sometimes these involve agreements between the government and a set of firms, but in other cases industry associations represent member firms. Sometimes the agreement only relates to general issues, such as R&D activities, reporting on emissions, or energy efficiency, but in other cases specific quantified targets, such as emissions targets, are agreed upon. A few VAs are legally binding once signed, but most are not.[50]

Although VAs are a relatively new environmental policy instrument, they are gaining popularity as a tool to cope with environmental issues. That in 1996 in the EU alone there existed more than 300 VAs at least suggests this type of policy measure is administratively and politically feasible, especially if it is used in a policy mix or in new policy areas (OECD, 1998a, p. 102). VAs are political feasible simply because most of the industries seem to prefer VAs over other tools (Dijkstra, 1998; Svendsen, 1999). VAs may precede more formal arrangements; the vast majority of GHG emissions reductions in the USA called for in the US Climate Change Action Plan come, for instance, from voluntary initiatives to increase energy efficiency. However, VAs may not be a satisfactory substitute for mandatory efficiency standards (Krause, 1996).

Sometimes the "voluntary" aspect of a VA is questioned, as the main motivation for industries to join the VA was to avoid the implementation of a carbon and/or energy tax and/or other mandatory policy (Torvanger and Skodvin. 1999, p. 28). Segerson and Miceli (1997) found that the level of abatement under a VA is closely related to the probability of regulatory action in the absence of an agreement.

Proponents of voluntary approaches point to the low transaction costs, the merits of the consensus elements in the approach, and the advantages of leaving the choice of abatement measures to the participants. Although free riding is a concern with VAs, the risk can be addressed through the proper design of the VA. Free riding can take place if firms that do not comply or participate benefit from the agreement while bearing no cost. Governments may encourage participation in VA programmes and discourage free riders by providing incentives such as permits to use labels and other marketing claims. As for possible abuse, some or all of the participants may use their initiating role in the process to create an agreement that benefits them, and hence obstruct real abatement progress. It could also involve introducing measures that benefit some firms, and reinforces their market dominance.

To assess the environmental effectiveness, the trade-off between how ambitious the objectives are and how well they are attained should be recognized. There is a suspicion that if the goals are too ambitious, they will not be attained. As most VAs are non-binding they may not attain ambitious goals (EEA, 1997; OECD, 1998a). VA objectives may be less stringent if environmental groups are left out off the negotiation process. Since VAs are a relatively new policy instrument to cope with environmental issues, it is too early to determine their effectiveness (OECD, 1998a, pp. 78–83).

From a methodological perspective, it is rather complex to assess the effectiveness of VAs because it is difficult to establish a counterfactual.[51]

Voluntary provisions also may accompany mandatory policies. The Substitution Provision of the US Acid Rain (SO_2 Emissions Trading) Program is the first example of a voluntary

[48] See Kopp *et al*. (1999b) for a discussion in the context of domestic US policy; Roberts and Spence (1976) provide a theoretical discussion.

[49] "For the purpose of this Communication Environmental Agreements … can also take the form of unilateral commitments on the part of industry recognized by the public authorities" (CEC, 1996, p. 5).

[50] In some countries (e.g., Denmark) negotiated agreements are explicitly linked to favourable treatment under tax regimes.

[51] The issue of counterfactual baselines is revisited in Section 6.3.2.3 in the context of the Kyoto mechanisms.

Box 6.3. Keidanren Voluntary Action Plan on the Environment (See http://www.keidanren.or.jp/)

Keidanren (Japan Federation of Economic Organizations), the largest private and non-profit economic organization in Japan, announced the "Keidanren Appeal on the Environment" in 1996, in which concrete courses of action for measures to cope with global warming were specified. Following the Appeal, 37 trade associations set forth the "Keidanren Voluntary Action Plan on the Environment" in June 1997. Although the above action plan is a unilateral commitment on the part of the industries, it should be considered an environmental agreement.[52] In fact it constitutes a major component of the Japanese government's "Basic Principles for the Promotion of Measures Dealing with Global Warming"; a follow-up survey is to be conducted every year and reported to the government councils, including the Industrial Structure Council of the Ministry of International Trade and Industry, for third party review.

This action plan, which contributes to meeting the Japanese commitment under the Kyoto Protocol, has as its goal "to endeavour to reduce CO_2 emissions from the 28 industrial and energy-conversion sectors to below the levels of 1990 by 2010." Under a baseline (or business-as-usual) scenario these emissions are estimated to increase by 10%. The 28 sectors represent approximately 76% of CO_2 emissions generated by all industry and energy-conversion sectors in Japan, which in turn generated 42% of Japan's total CO_2 emissions in 1990.

Each participating business sector made a social commitment by setting a numerical target (in terms of: size of CO_2 or energy consumption; emissions or index of CO_2 emissions; or energy input per unit output), which was compiled and published by Keidanren. For example, the Japanese Iron and Steel Federation set a target of reducing energy consumption in 2010 by 10% from the 1990 level (57.22kt crude oil).

The second survey, presented just before CoP5, showed that CO_2 emissions in fiscal year 1998 were 126MtC, or 2.4% less than 1990 and 6% less than 1997 levels. Keidanren stressed that to meet the emissions goal it would:
- continue to make annual surveys of emissions by participating associations;
- intensify co-operation between the government and other sectors, such as transportation, households, *etc*.;
- promote the construction of new nuclear power plants; and
- explore positively the utilization of the Kyoto mechanisms.

compliance provision within an emissions trading regime.[53] Voluntary compliance was characterized by adverse selection; units that "opted in" to the programme tended either to have low emissions below their permitted allocations, or to have low costs of abatement (Montero, 1999). While the VA kept aggregate costs low, the adverse selection increased aggregate emissions (Montero, 1999). This inevitable trade-off between adverse selection and cost-savings means that the design of voluntary programmes will influence their net emissions impact (Montero, 2000a).

The OECD (1998a) noted that no empirical evidence is available on the cost-effectiveness of VAs. CEC (1996), however, argues that the flexibility of VAs provides room for industries to find the most efficient way to achieve the targets, which could be a major advantage. EEA (1997) recently concluded, after analyzing six case studies of European VAs, that, while there was quantitative evidence for environmental improvement in most case studies, more sophisticated analysis would be necessary to distinguish between the effects of the VAs and those of other factors (EEA, 1997, pp. 84–85). In the same study it was recognized, however, that in five of the six cases the interviewed experts felt VAs incurred lower costs than alternative instruments.

OECD has indicated various conditions under which VAs can be implemented most effectively (EEA, 1997, p. 15; OECD, 1998a):
- clear targets are set prior to the agreement;
- the agreement specifies the baseline against which improvements will be measured;
- the agreement specifies reliable and clear monitoring and reporting mechanisms;
- technical solutions are available to reach the agreed target;
- costs of complying with the VA are limited and are relatively similar for all members of the target group; and
- third parties are involved in the design and application of VAs.

The EC, for instance, recommends prior consultation with interested parties, a binding form, quantified and staged objectives, the monitoring of results, and so on.

[52] This point of view is supported by the EC: "For the purpose of this Communication Environmental Agreements … can also take the form of unilateral commitments on the part of industry recognized by the public authorities" (CEC, 1996, p. 5).

[53] The SO_2 emissions trading regime has been implemented in two phases. The first phase (beginning in 1995) imposed annual emissions caps (with trading) on the 263 dirtiest large electricity-generating units. The Substitution Provision allowed units regulated only by the second phase (beginning in 2000) to voluntarily "opt in" in the first phase. Owners of the first-phase plants could use these "substitution" units to lower the compliance costs.

Box 6.4. Voluntary Agreements in the Netherlands

In the early 1990s, the Dutch government entered into agreements with all energy-intensive industries to improve energy efficiency. The purpose was both to improve competitiveness by cutting energy costs and to reduce CO_2 emissions. This win–win situation is favoured by the Ministry of Economic Affairs, which was primarily responsible for the execution of the long-term agreement (LTA) policy. Efficiency is usually defined as the ratio of relevant physical output to primary energy consumed. The target for most sectors is to improve energy efficiency by 20% in 2000, compared to 1989. Most sectors were audited before entering into an agreement, to ensure that the efficiency improvement was feasible. The coverage of industrial energy consumption is high, almost 90% when non-energy consumption is excluded. There is a similar agreement with the horticultural greenhouse sector, which is the second largest energy-consuming sector after the chemical industry. An intermediate organization co-ordinates the annual monitoring and runs programmes for technological support and R&D. The government publishes results annually. It is expected that, on average, the 2000 efficiency target will be reached.[54] Based on interviews and analysis, 30%–50% of the efficiency improvement identified is implemented because of LTA and related supporting policies (Glasbergen *et al.*, 1997). The results for the LTA sectors in total manufacturing industry through 1996 are depicted in *Figure 6.1*, together with general statistics (Van Dril, 2000).

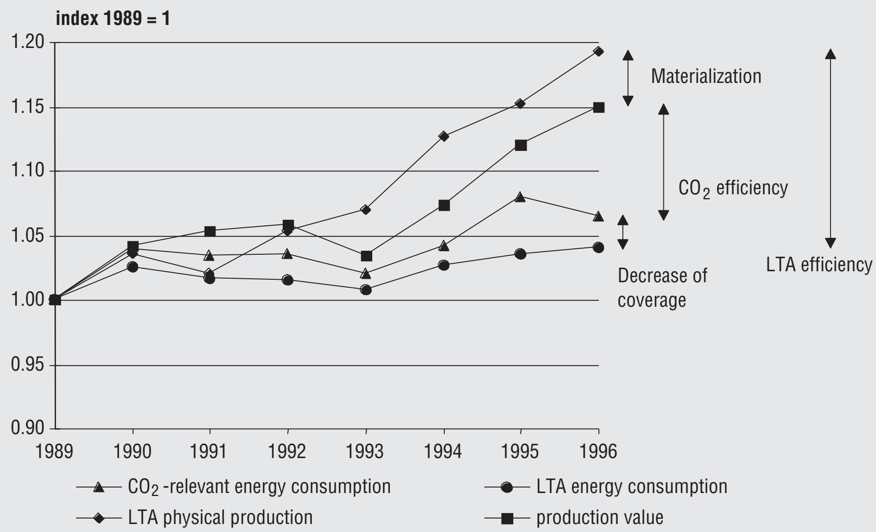

Figure 6.1: *Aggregated results of manufacturing industry LTAs and statistics.*

As a general observation, LTA results diverge from the actual average of the entire manufacturing sector. Both the energy and output indicators show significant deviations. The main explanations for the divergence are, first, that energy-intensive products such as primary materials have grown faster than average production value. In monitoring practice, there may be some bias towards adjusting for energy-intensive products, to avoid negative effects on efficiency results. A second explanation is that statistics on the chemical industries are unreliable and that no insight is provided by the entities responsible for monitoring. For example, no clear information is available on the share of non-energy consumption and its impact on CO_2 emissions.

6.2.2.5 Informational Instruments

As Chapter 5 shows, information drives decisions. Information gaps result in uncertainties, risks, and missed opportunities. Poor information is widely recognized as a barrier to improved energy efficiency or reduced emissions (Tietenberg and Wheeler, 2000). Markets are not always fully informed on the quality of information and application of decision-support technologies. In Russia, for instance, it is estimated that institutional barriers and information limitations result in only 2% of the market potential to improve energy efficiency actually being realized (Bashmakov, 1998).[55]

Reliable data are a prerequisite for decision-making. At the micro level, feasibility studies or business plans are used to explore opportunities to raise energy efficiency and energy productivity. They are based on metering and energy audits in specific situations. At the macro level, detailed statistical data on major aspects of energy consumption are the basis for development and evaluation of efficiency improvement policies, and

[54] Ministry of Economic Affairs, Netherlands (1999): Long-term agreements on energy efficiency, results (published annually).

[55] OECD/IEA (1997) includes 47 case studies of successful energy-efficiency improvement projects and policies.

their success or failure (Japan Energy Conservation Center, 1997). Comparisons between nations and companies and benchmarking on energy efficiency indicators also raise awareness and allow for better determination of efficiency potentials (see also OECD/IEA, 1997; Fenden, 1998, p. 203; Phylipsen *et al*., 1998, p. 230; ADEME-European Commission, 1999). Also, improved accessibility to new technology information enhances technology transfer. Information-based policies can also be used to reveal low levels of performance.

Policy instruments to improve information are applied on three levels. First, they are used to raise awareness of climate issues. Governments communicate their targets and policy measures to the public. The information may influence preferences to contribute to GHG mitigation. Social marketing is becoming a crucial instrument in creating an appropriate social environment for GHG emissions reduction policies (Legro *et al.*, 1999). Second, governments stimulate research to analyze climate issues and create mitigation opportunities that can be widely applied. R&D generates new information on possibilities and determines the technical potential. Information on the economic situation (prices, taxes, interests rates, etc.) in turn constrains the technical potential to what is commercially feasible. Third, information instruments are used to help the implementation of measures. They can assist the public in making the right choices with respect to GHG mitigation.

There are several reasons for using instruments to further information on climate issues. First, climate change involves complex negative externalities, so the process of policymaking with regards to GHG reduction needs broad support and understanding. Second, information, once generated, can be widely used, which is regarded as a reason for collective funding of its collection, dissemination, and use. Many of the possible ways to reduce GHG emissions are similar all over the world. Markets for this information are not yet developed.

6.2.2.5.1 Education Programmes

Energy efficiency centres, government offices, utilities, equipment vendors, professional organizations and associations, educational channels, etc., deliver information on GHG reduction. Improved data and metering, energy audits and monitoring, workshops and exhibitions, campaigns in the mass media, education and training, efficiency and environmental labelling, publications and databases are all typical instruments used to enhance information dissemination.

Educational and training programmes may improve decision making and can have long-lasting effects. Consumer education is an important social marketing tool in implementing DSM programmes (see *Box 6.5*).

Information campaigns are used as marketing elements in most energy efficiency programmes. Typical examples of such campaigns are:

- publications and advertising;
- broadcasting of special programmes on television and radio;
- distribution of special brochures;
- creation of special easily accessible databases; and
- public awareness programmes, such as “Energy Conservation Day” and “Energy Conservation Month”, which are implemented on a regular basis at the national level in Japan and South Korea.

Box 6.5. Public Education Component of Poland Efficient Lighting Project (OECD/IEA, 1997, p. 480)

The IFC/GEF Poland Efficient Lighting Project (PELP) was designed to reduce emissions of CO_2 and other GHGs emitted by Poland’s electricity sector by stimulating the Polish consumer market for energy-efficient compact fluorescent lamps (CFLs). The public education component of PELP promoted the CFL subsidy programme to the public by providing consumer information on the benefits of energy-efficient lighting from a trustworthy, non-industry source. The generic PELP advertising bore the logos and endorsement of four respected Polish organizations. The PELP logo featured in advertisements and on participating products, was promoted as a symbol by which consumers could identify energy efficient, high-quality products. PELP organized high-level seminars for lighting professionals on technical and design aspects of energy-efficient lighting. Finally, to educate tomorrow’s consumers on the benefits of CFLs, PELP created an energy-efficiency curriculum for schools, and sponsored an art and essay competition for schools on energy-efficient lighting.

Publication of books and periodicals on energy-efficient technologies and systems, and energy efficiency success stories, guidelines, and policies is another powerful information instrument.[56] Costs of information programmes vary according to their scale, coverage of specific groups of customers, and use of media.

6.2.2.5.2 Labelling

One instrument that is increasingly applied in the area of environmental policy is environmental and energy efficiency labelling. Labelling programmes can be mandatory or voluntary.[57] Mandatory energy efficiency labels have long been estab-

[56] The Russian Center for Energy Efficiency, for instance, since 1993 has published the “Energy Efficiency” quarterly bulletin. This stimulated regional energy-efficiency legislation, policies, and programmes in Russia. The bulletin is available on the Internet at http://www.glasnet.ru/~cenef.

[57] Mandatory labelling programmes are under implementation not only at a national level (e.g., *Energy Guide* in the USA), but also internationally, such as “SAVE” in the EU. Voluntary labelling programmes were also initially launched at the national level, such as “Blue Angel” in Germany and “Power Smart” and “EcoLogo” in Canada, but then some were internationalized (e.g. the originally US “Energy Star” programme for office equipment was introduced in Japan).

lished in the USA, Japan, and South Korea, and recently in the EU where they are part of appliance and automobile efficiency legislation. Labels and marketing may have a pervasive impact on consumers' behaviour and the introduction of clean technology. *Boxes 6.5* and *6.7* provide some examples of such developments to illustrate how these phenomena work in practice. The strengths of energy efficiency and environmental labelling are, first, that labels do not distort the market. Second, in many instances they are voluntary for both the producer and the consumer because the former is free to decide whether or not to join the system and the consumer is free to decide whether or not to buy the labelled product. Voluntary labels are a non-official instrument, and may be instituted without the usual delays associated with official policymaking. Third, labels are usually based on considerable information exchange among the various stakeholders, which may increase the overall acceptance of the instrument.

This is not to say, however, that energy efficiency and environmental labelling do not have weaknesses. If all products are labelled, the consumer must learn how to interpret the label (e.g., do higher numerical values indicate a better or worse product?). If products must meet a specified standard to qualify for a label, only part of the market will be covered by the labelled product. Competing labels for the same product or less reliable labels may easily undermine the trust of the consumers in the labelling instrument. This may turn out to be an inherent limitation.

In sum, environmental labels represent an important tool to create transparency in markets and thus give orientation to the consumer. The overall success of this instrument, however, will probably depend on the solution to the following dilemma: if applied too strictly, market coverage may be too low for the label to be effective; if applied too leniently, the environmental effectiveness may be limited.

6.2.2.6 Subsidies and Other Incentives

6.2.2.6.1 Environmental Subsidies

A subsidy for GHG emissions reduction pays entities a specific amount per tonne of CO_{2eq} for every tonne of GHG reduced or sequestered. Such a subsidy encourages implementation of measures to reduce emissions or enhance sequestration that are less costly than the subsidy.

Under certain circumstances, a uniform subsidy can lead to the same emissions reduction outcome as an equivalent uniform tax. In theory, in an industry with homogeneous firms, both taxes and subsidies (set at the same levels) yield exactly the same outcome in the short run. In general, a tax is more efficient than a subsidy because the subsidy can result in too many firms in the industry, and thus an inefficient amount of both pollution and goods associated with the pollution (Kolstad, 2000). This is always the case in the long run because a subsidy lowers the average cost of production, while the tax increases the average cost of production. In the short run, it is also the case in an industry with heterogeneous firms. A subsidy may allow some firms to continue operating that would not continue in the case of a tax (those with average variable costs above prices). Besides, a subsidy requires that revenue be raised somewhere else in the economy, which can also produce dead-weight losses.

Table 6.1: *Public expenditures as percentage of gross domestic expenditures on R&D (1985–1995) (OECD, 1998a)*

Country/ region	**1985 Public % of total**	**1990 Public % of total**	**1995 Public % of total**
Overall OECD	43.0	37.8	34.5
USA	50.3	43.8	36.1
Canada	48.9	44.3	37.7
EU	44.4	40.9	33.1
UK	42.2	35.5	33.3
France	52.9	48.3	–
Japan	21.0	–	22.4
Germany	37.6	33.9	37.1
South Korea	–	17.0	18.2
Czech Republic	–	30.6	34.9
India	88.5	87.3	84.6

An emissions reduction subsidy, like an emissions tax, does not guarantee a particular level of emissions. Therefore, it may be necessary to adjust the subsidy level to meet an internationally agreed emissions commitment. In addition, criteria other than efficiency, such as distributional impacts, are likely to influence the design of the emissions subsidy (or the combination of subsidies and taxes in what is known as fee and/or rebate). The distributional and competitiveness impacts help explain why, in practice, some energy and emissions taxes are coupled with tax exemptions or subsidies. Also, the use of subsidies for environmental purposes may cause problems under WTO agreements on subsidies and countervailing measures.

6.2.2.6.2 Research and Development Policies

Technological progress is mainly achieved in the private sector, through learning by doing, incorporating new findings developed elsewhere into the production process, or through firms own R&D activities. A major, and generally increasing, part of funding of R&D expenditures is initiated by and in the private sector itself (*Table 6.1*). Government funding of R&D on energy has historically favoured nuclear and coal technologies (IEA, 1998a; OECD, 1998a). Research on renewable energy and energy-efficient technologies is gaining ground, but it is still a relatively small portion of R&D budgets in the OECD. This is important when assessing what governments can do to promote innovation. Perhaps governments can provide a reliable legal framework to protect research findings in the area of energy efficiency improvement from being copied elsewhere without compensation.[58]

6.2.2.6.3 Green Power

Green power policies establish mechanisms through which part of the electricity supply (whether in a regulated or competitive environment) must come from designated renewable energy sources. Regulatory policy mandates include set-asides for renewables, renewable portfolio standards (RPSs), and various kinds of subsidies created from SBCs or renewable energy funds. The cost of compliance for policy mandates is borne by all consumers. Despite this 100% participation, however, the policies may or may not be effective in stimulating renewable energy generation, depending on how aggressive they are and how they are implemented. Some examples are given in *Boxes 6.6* and *6.8*. To reduce the cost of compliance regulatory policy may be supplemented by tradable renewable energy certificates as described in *Box 6.7*.

Green power and green pricing programmes encourage consumers to voluntarily pay a higher price for electricity generated from "green" (environmentally friendly) energy sources. Green power products are offered by some suppliers where electricity markets have been liberalized, while green pricing is a green power option offered by the monopoly utility in jurisdictions where consumers are not yet permitted to choose their retail provider (Swezey and Bird, 2000). Green power marketing programmes are relatively new, dating from 1993, and are being implemented in Australia, Canada, Germany, Netherlands, Switzerland, UK, and USA (Markard, 1998; Crawford-Smith, 1999; Holt, 2000a, 2000b).

In the USA, about 30 green power products are being marketed by 15 retailers in competitive states and about 140 electric utilities offer a green pricing option that emphasizes wind or photovoltaics (Holt and Wiser, 1998; Holt, 2000b). Market penetration so far is low, a little over 1% on average, although it reaches as high as 4%–5% for a few utility programmes (Wortmann *et al*., 1996; Holt, 2000a, 2000b). Of those who switch suppliers in competitive markets, some 20%–95% choose a green power product (the higher percentage results from significant renewable energy subsidies in California).

Wiser *et al*. (2000) assessed green power marketing programmes in the USA. They conclude that the collective impact of customer-driven demand for renewable energy has been modest to date, but that it is too early to draw definitive conclusions about the potential contribution of green power marketing in the long run.

In support of green power marketing and of policies that mandate renewable set-asides and RPSs, renewable energy certificates (also called credits, labels, or tags) may be traded separately from green electricity. Whether renewable energy or other environmental attributes should remain with the purchaser of the underlying commodity, or be sold to different entities, is under debate. There are either plans for or limited experience with tradable certificates in Belgium, Denmark, Italy, Netherlands, UK, and USA, and it is likely to grow in importance (Benner, 2000; Rucker, 2000). Trading in renewable energy certificates promises greater liquidity and potentially lower costs to meet policy commitments and marketing claims. An example is given in *Box 6.7*.

6.2.2.6.4 Demand-side Management

Information programmes are often applied in combination with other initiatives (such as rebating in DSM programmes, energy audits, labelling, and regulation). In the US cumulative electric utility DSM spending to date is about US$15–20 billion. Close to 60% of utility customers are served by such programmes. Reductions in national electricity demand of 3%–4% percent were achieved with these programmes (Hadley and Hirst, 1995; Eto *et al*., 1996). Studies on the efficiency of DSM programmes find that a large proportion of the reported conservation impacts are statistically observable after accounting for economic and weather effects (Parfomak and Lave, 1997).

With utility restructuring and the emergence of electricity generation competition, the rationale of utility resource acquisition has been greatly diminished. The new generation of programmes funded by SBCs emphasizes permanent market transformation effects aimed at technology manufacturers, including financial incentives paid directly to manufacturers, guaranteed minimum market sales for new energy efficient products, and competitive technology procurement programmes.

6.2.3 Mixes of National Policy Instruments

Section 6.2.2 discusses various policy instruments to manage GHG emissions in isolation. Various authors (e.g., Bernstein, 1993; Richards, 1998; Stavins, 1998b) argue that to select the best approach to attain the environmental goal, various cost and other aspects must be taken into account. These include production costs, cost differences across sources, transaction costs, monitoring and enforcement costs, implementation, administrative costs, and other socio-economic conditions idiosyncratic to each country. For these reasons, it can be anticipated that in most countries GHG emissions will be managed using a portfolio of policy instruments, rather than a single policy instrument. Furthermore, the portfolio of instruments is likely to differ from country to country. Using a portfolio of policy instruments enables a government to combine the strengths, while compensating for the weaknesses, of individual policy instruments, thus improving overall effectiveness and efficiency.

Under some conditions a combination of market-based and information policies and regulations can improve economic

[58] For some additional remarks see also Section 6.5.3.

Box 6.6. Examples of Policies to Promote Renewables in a Liberalized Power Market

Renewables Set-aside
The UK has been promoting wind and other renewable energy technologies through its Non Fossil Fuel Obligation (NFFO; see Mitchell, 1995a, 1997). The renewable NFFO sets aside a certain portion of the electricity market to be supplied by designated renewable energy technologies under a competitive bidding framework. Within each technology band (wind, biomass, landfills, solar, etc.) developers submit bids of proposed projects and the projects with the lowest cost/kWh price are awarded power purchase contracts. Regional electricity companies are mandated to purchase power from NFFO-awarded renewable electricity generators at a premium price. The companies are reimbursed for the difference between the NFFO premium price and the average monthly power pool purchasing price through the Fossil Fuel Levy (Mitchell, 1995a). The main weakness of the NFFO is that the implementation rate of approved projects is very low, because bids have such low cost/kWh that they do not allow the profitable operation of projects. Moreover, the intermittent character of NFFO rounds has precluded the development of a steady domestic market for renewable technologies (Michaelowa, 2000).

Renewable Portfolio Standard (RPS)
The RPS has received considerable attention in the USA. The RPS is similar to the NFFO concept in the UK, in that both are competitive least-cost mechanisms. Unlike NFFO there is no funding levy. Under RPS, all retail power suppliers are required to obtain a certain minimum percentage (e.g. 5%) of their electricity from specified renewable energy sources. Efficiency is obtained by allowing the market to determine the most cost-effective solution for each electricity retailer (Radar, 1996; Haddad and Jefferis, 1999). State legislatures and/or public utility commissions have approved various versions of RPS in several US states (Wiser, 1999b).

Production Subsidy and/or System-benefit Charges (SBCs)
Another support mechanism to promote renewables in a liberalized electricity market is a fee/kWh on all energy users to support renewable energy development. This charge is often referred to as SBCs (Haddad and Jefferis, 1999). In California, a total of US$540 million collected from 1998 up to 2002 from electricity customers is directed to support existing, new, and emerging renewable electricity generation technologies (California Assembly Bill, 1996, AB 1890, Ch. 854, Sec. 381). In addition, nine other states in the USA have established SBC policies under the restructuring of their electric utility industries to promote the use of renewables (Wiser, 1999b). Unlike in NFFO and RPS, there is no supplier obligation.

Box 6.7. Green Certificates for Wind Energy in the Netherlands

Support for wind energy in the Netherlands has included both R&D grants and a variety of market-stimulation mechanisms. These have included an integrated programme for wind energy, which provided subsidies of 35–40% of investment costs for newly built turbines. Electricity distribution companies raised environmental levies to purchase wind generated kiloWatt hours for high guaranteed prices (about US$0.07; Wolsink, 1996). More recently, however, significant changes have occurred in the Dutch renewable energy policy, reinforced by the liberalization of the electricity market. Most of the direct subsidies are now eliminated and other market-oriented and fiscal mechanisms introduced. One such mechanism is the green certificates market, which started in 1998. By law, local energy distribution companies must purchase renewable electricity from independent power generators. Distribution companies issue green certificates to the renewable generators equal to the amount of renewable kiloWatt hours sold to the grid. The renewable generator can then sell these green certificates on an open market to distribution companies that want to sell green-certified electricity (Schaeffer *et al.*, 1999). Green electricity is exempt from energy taxes, which will be raised to about US$0.06/kWh in 2001. The tax exemption makes wind energy competitive with electricity from conventional sources, and thus the subsidies are obsolete.

efficiency. Well-designed policies aimed at energy prices are economically most efficient when transaction costs are low and/or cannot be substantially reduced through market transformation policies. They also work best when the potential for technological learning by doing is small or known with reasonable certainty. Well-designed regulatory and incentives-based policies aimed at factors other than energy prices are economically most efficient when the transaction costs are large and can be substantially reduced at low administrative cost. They also work best when the potential for technological learning by doing is large. Virtually all end-use markets for energy efficiency suffer from high transaction costs and related market problems. Also, many energy efficiency and renewables technologies exhibit large potentials for learning by doing. The most effective and economically efficient approach to achieve lower energy sector emissions is to apply market-based instruments, standards, and information policies in combination. Policies to administer energy price changes provide a uniform signal to all economic actors and overcome fragmentation. Standards and information policies can move the economy closer to the frontier of production possibilities, which raises total factor productivity.

Overriding non-economic reasons may also exist for combining different types of policy instruments to manage GHG mitigation. First, the number and diversity of sources is large and even

Box 6.8. Renewable Energy Policy in India

Renewable energy (RE) sources were first recognized and incorporated in official policy documents in the early 1970s. Several national-level programmes for RE technologies have been initiated, for example, the National Project for Biogas Development (NPBD) with a target of 1.5 million plants by 2001, a national programme for improved cook-stoves, a programme for mass demonstration of RE sources like wind, solar, biomass, *etc*. The Ministry of Non-conventional Energy Sources (MNES) co-ordinates and implements the RE policy at the national level with counter-part departments in the state governments. The Indian Renewable Energy Development Agency (IREDA) operates a revolving fund for development, promotion, and commercialization of RE through the provision of soft term financial assistance.

Under the New Strategy and Action Plan for RE, the following, two-pronged action plan was devised:

- High priority accorded to generation of grid-quality power from wind energy, small hydropower, bio-energy and solar energy.
- Rural energization programme is promoted through:
  - electrification of villages through photovoltaic and biomass gasifier power systems,
  - supply of solar lanterns to unelectrified households,
  - use of solar water heating systems,
  - rural energy programmes, for example, National Project on Biogas Development,
  - production of energy from agricultural waste, *etc*.

Currently, a three-fold strategy has been pursued by the government for promotion of RE sources through private sector involvement. These include:

- Providing budgetary resources by government for demonstration projects.
- Extending institutional finance from IREDA and other financial institutions for commercially viable projects, with private sector participation; and external assistance from international and bilateral agencies.
- Promoting private investment through fiscal incentives, tax holidays, depreciation allowance, facilities for wheeling and banking of power for the grid and remunerative returns for power provided to the grid. The emphasis has shifted from direct financial incentives (e.g., subsidies) to indirect fiscal incentives (e.g., low interest loans, financing packages for consumers, reduced tariff and taxes, viable power-purchase prices, *etc*.). Some fiscal incentives include: accelerated 100% depreciation on specified renewable energy based devices/projects, 100% tax deduction from profits and gains for first five years of operation, and 30% for the next five years for industrial undertakings set up for generation and/or distribution of power.

The new policy for RE tried to give a focus on commercialization and, market orientation and to encourage greater private sector involvement. Despite this there exists significant unexploited potential. The main barriers are: high initial and transaction costs, under-developed markets and market-support infrastructure for RE products, weak linkages between market development and R&D, product development not responsive to users' needs, and the pricing of conventional energy sources (TERI, 2000).

the most comprehensive instruments (an emissions tax or a tradable permit system) is not suitable for all of these sources. Second, the conditions needed to administer efficiently these comprehensive instruments (e.g., a manageable number of participants, but enough to create a competitive market for a tradable permit system) may reduce the scope of their application. Third, different policy instruments can be used to distribute the mitigation-cost burden across sources in ways that lessen opposition to the policy goal. Fourth, policy instruments have multiple impacts, so different instruments and sets of impacts are preferred for different sources. Finally, governments have frequently adopted a portfolio of policies, rather than a single policy instrument, to deal with complex environmental issues.

One important aspect in the policy analysis has been a shift of attention from the assessment of single policy instruments to questions of the optimal policy mix (OECD, 1996b). Assessing the performance of particular environmental policy instruments from historical evidence is difficult because these were often combined in policy packages, as was the case with the phase-down of leaded petrol in a number of European countries. Econometric analysis has been employed to separate out the effects of individual policy instruments under such conditions, but this is not always possible (Katsoulacos and Xepapadeas, 1996; Boom, 1998).

6.3 International Policies, Measures, and Instruments

Although only Annex I Parties that have made commitments under the Kyoto Protocol's Annex B have quantified emissions limitations, all Parties have committed to take climate change considerations into account, to the extent feasible, in their relevant social, economic, and environmental policies and actions (UNFCCC, 1992, Article 4.1.f). It is recognized, however, that non-Annex I Parties' efforts to take actions that contribute to national development and GHG emissions reduction may be limited by capital constraints, lack of knowledge, or other factors. The UNFCCC and the Kyoto Protocol, therefore, include several provisions that can help overcome such barriers, such as the provision that:

- All Parties are "committed to promote and co-operate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the energy, transport, industry, agriculture, forestry and waste management sectors" (UNFCCC, 1992, Article 4.1.c).
- Parties agreed to establish a financial mechanism "for the provision of financial resources on a grant or concessional basis, including for the transfer of technology" (UNFCCC, 1992, Article 11.1).

Additionally,

- "The CDM created by the Kyoto Protocol creates an incentive for (entities in and governments of) Annex I Parties to assist the development and implementation of climate change mitigation projects that contribute to sustainable development in, and are approved by, a non-Annex I Party" (UNFCCC, 1997, Article 12).

This section discusses the three Kyoto mechanisms: international emissions trading (IET) (Article 17) in Section 6.3.1 (for some clarifying remarks, see also Section 6.1.3), and JI (Article 6) and the CDM (Article 12) in Section 6.3.2. Thereafter, the section deals with international transfers (Section 6.3.3) and with the various other international policies, measures, and instruments (Section 6.3.4).

6.3.1 International Emissions Trading

If the Kyoto Protocol comes into force Annex I Parties will have agreed to an allocation of AAs (here also called emission quotas) of GHG emissions for the first commitment period, 2008 to 2012. Article 17 of the Protocol allows them to trade part of these emission quotas among themselves in accordance with rules currently being negotiated.[59]

IET implies that countries with high marginal abatement costs (MACs) may acquire emission reductions from countries with low MACs. In principle, such trading tends to equalize MACs across these countries, so that an aggregate emissions reduction can be attained cost-effectively.[60] Parties have not yet decided whether IET based on Article 17 will be restricted to governments or whether legal entities also will be allowed to participate with the approval of their national governments. To support compliance with their AAs after adjusting for trading, governments may use any of the domestic policy instruments discussed in Section 6.2 above.

Limiting all transactions to multilateral and potentially anonymous trade on an exchange would help IET move in the direction of becoming efficient and non-discriminatory. Bilateral trading cannot be relied upon to reveal to others the true full transaction prices (including undisclosed side-payments), which is required to give all participants equal access to gains from trade. Non-anonymous trading may eliminate transactions between Parties who are in conflict with each other, thus reducing market efficiency. Transparent, anonymous, and efficient trading would be possible on a continuous stock-exchange kind of market (Bohm, 1998). The scope for the exertion of market power is small on such markets, contributing to efficiency (Smith and Williams, 1982).

According to Article 17 in the Protocol, "any such trading shall be supplemental to domestic actions for the purpose of meeting quantified emission limitation and reduction commitments." How to implement this provision is still under debate.[61] A restriction on free IET as a result of binding supplementarity requirements could prohibit equalization of the MACs across participating countries, and hence increase aggregate abatement costs.[62]

It has also been argued that constraints on the use of IET and the project-based Kyoto mechanisms (see also Section 6.3.2) might accelerate technological innovation in Annex I countries by increasing the relative price of alternative options for carbon mitigation. Limited analytical studies are inconclusive as to whether such constraints will induce significant innovation, but do suggest that they could reduce the flow of technology to other countries.

An initial quota allocation that turns out to exceed a baseline projection for a country's emissions–possibly relevant for some signatories of the Kyoto Protocol with substantial changes in political and economic systems since 1990–implies that sales of AA units (AAUs) will exceed emission reductions because of active climate mitigation policies, sometimes referred to as "hot air". Restricting trade of "hot air", as some Parties have proposed, would force larger reductions in emis-

[59] With sufficient incentives, some non-Annex I Parties may ask to join in IET, replacing their expected use of the CDM, which is discussed in Section 6.3.2.2 (Barros and Conte Grand, 1999; Bohm and Carlén, 2000; Montero *et al*., 2000).

[60] For illustrations of the potential gains from IET, see Bohm (1997), Manne and Richels (1999), and Weyant and Hill (1999).

[61] Each of the mechanisms, not just IET, includes a so-called supplementarity provision, although the wording differs in the case of the CDM. Some Parties have proposed rules to address supplementarity that apply an overall limit on the use of the three mechanisms, rather than a separate limit for each mechanism.

[62] For a preliminary estimate of the cost implications of the EU proposal for the definition of supplementarity, see Baron *et al*. (1999), Bernstein *et al*. (1999), Criqui *et al*. (1999), and Ellerman and Wing (2000). See Woerdman (2000) and Michaelowa and Dutschke (1999a) on additional reasons for supplementarity.

sions by countries that would otherwise import emissions quotas during the first commitment period.[63] In addition, constraints on hot-air trading, other things being equal, would make the Protocol less beneficial for some countries with "hot air" allocations (Bohm, 1999).

Emissions trading creates a risk that sellers of AAUs might not undertake the emissions reductions that their sales require, in spite of the political costs of non-compliance and despite the sanctions to be instituted. Several options that provide Annex I Parties with an incentive to transfer only part of their AAUs that are surplus to their compliance needs are under consideration. Such options, called liability provisions, are discussed in Section 6.3.5.3. Liability provisions are intended to enhance environmental integrity and are also necessary for the functioning of the market.

6.3.2 Project-based Mechanisms (Joint Implementation and the Clean Development Mechanism)

Project-based mechanisms allow actions that reduce GHG emissions from, or enhance sinks beyond, what would otherwise occur to receive "credits" for the emissions mitigated; these credits can be used by Annex I Parties to help meet their emissions limitation commitments. These mechanisms include technology transfer and provide opportunities for mutual co-operation. JI involves emissions reduction or sink enhancement projects in Annex I countries. CDM involves emissions mitigation projects in non-Annex I countries.[64] Central to these mechanisms is the operational definition of what emissions would have been in the absence of the project; the baseline from which emission reductions (or sink enhancements) are measured. This section focuses on setting the baselines for crediting.

6.3.2.1 Joint Implementation (Article 6)

Article 6 of the Kyoto Protocol allows an Annex I country to contribute to the implementation of a project to reduce emissions (or enhance a sink) in another Annex I country and to receive emission reduction units (ERUs) equal to part or all of the emission reduction (sink enhancement) achieved. The ERUs received by the investor country can be used to help meet its national emissions limitation commitment.

In the case of JI, some analysts have suggested that an independent authority responsible for approving the project baseline is needed in addition to the Parties' approval of the project. Others argue that the host government has an incentive to ensure that ERUs are issued for real emission reductions only if the government is bound to strong and credible penalties for non-compliance (see also Section 6.3.5).

Numerous issues related to JI remain to be agreed, including:
- host and project eligibility;
- the possibility of awarding ERUs for emission reductions from JI projects prior to the start of the first commitment period (see Parkinson *et al*., 1999);
- monitoring, verification, and reporting requirements;
- baseline updating frequency;
- ERU approval, registry, and trading conditions;
- supplementarity provisions; and
- incentives for compliance.

6.3.2.2 The Clean Development Mechanism (Article 12)

The purposes of the CDM are to assist non-Annex I Parties to achieve sustainable development and to contribute to the ultimate objective of the Convention while assisting compliance by Annex I Parties (UNFCCC, 1997, Article 12.2). The CDM allows a project to reduce emissions, or possibly to enhance sinks, in a country without a national commitment to generate certified emission reductions (CERs) equal to the reduction achieved.[65] Annex I Parties can use CERs to meet national emissions limitation commitments. In contrast to JI, for which there is little peer-reviewed literature, the literature is rapidly growing on the CDM (Goldemberg, 1998; Michaelowa and Dutschke, 1998; TERI, 1998; Hassing and Mendis, 1999; Jepma and van der Gaast, 1999; Haites and Yamin, 2000).

A process for independent review of the certification of the emission reductions achieved is necessary for the credibility of the CDM. Article 12.4 establishes an executive board for the CDM and Article 12.5 specifies that emission reductions must represent real, measurable, and long-term benefits related to the mitigation of climate change and be certified by designated operational entities. The certification process and the respective roles of the operational entities and the executive board remain to be defined, but they will be critical.

The host government must approve proposed CDM projects. As part of its approval process it will need to assess whether the proposed project contributes to sustainable development (Matsuo, 1998; Begg, *et al.,* 2000). Some Parties have proposed criteria or procedures that the host government be required to follow when determining whether a project contributes to sustainable development of the country (see also Thorne and La Rovere, 1999; Chadwick, *et al*., 2000; Begg, *et al*., 2000).

[63] The EU proposal to address supplementarity, for example, includes a provision that limits the transfers of quotas and thereby limits the trade of "hot air". Restricting trade of "hot air" allows these AAs to be banked for use or sale during future commitment periods, thus reducing the cost of compliance from what it otherwise would be during the future periods.

[64] Whether sink-enhancement projects are eligible under the CDM is still being negotiated.

[65] How CDM projects can be financed is still being negotiated. See Haites and Yamin (2000) for a summary of options.

Investments in CDM projects by Annex I governments could lead to a reduction in their official development assistance (ODA).[66] The effect of government investment in CDM projects on the level of ODA will be difficult to determine since the level of ODA in the absence of CDM projects is unobservable. However, historical figures compiled by the OECD Development Assistance Committee could be used to try to deal with this.

Article 12.8 specifies that a share of the proceeds from CDM projects will be used to cover administrative expenses and to assist developing country Parties that are particularly vulnerable to the adverse effects of climate change to meet the costs of adaptation. Articles 6 and 17 do not impose a comparable levy on JI projects or international transfers of AAUs, although a number of developing countries have proposed that the levy be applied to all three mechanisms.

CDM projects can begin to create CERs upon ratification of the Kyoto Protocol. The advantage is that it supports developing countries obtaining access to cleaner technologies earlier. It means that a supply of CERs should be available prior to the start of the 2008 to 2012 commitment period when they can be used by Annex I Parties.[67] Parkinson *et al.* (1999) argue that creation of CERs during 2000 to 2007, which are credited towards 2008 to 2012 compliance, increases the emissions trajectories of Annex I countries for 2000 to 2012. They estimate that increased Annex I emissions offset 30–60% of the CERs created during 2000 to 2012.

Some analysts argue that the CDM facilitates the transfer of CERs from low-cost emission reduction actions to Annex I investors when they might subsequently be needed by the host government to meet a future emissions limitation commitment. However, this assumes a fixed stock of emission reduction actions. In practice, the stock of possible emission reduction (or possibly sink enhancement) actions changes over time in response to turnover of the capital stock, technological change, and other developments. Rose *et al.* (1999) analyzes the optimal strategy for a host government given a dynamic stock of potential projects.[68]

Numerous issues related to implementation of the CDM remain to be negotiated, including:

- host and project eligibility;
- eligibility of sequestration actions;
- demonstrating contribution to sustainable development;
- project financing arrangements;
- monitoring, verification, and reporting requirements;
- baseline establishment;
- CER certification, registry, and trading conditions;
- the share of proceeds for administrative expenses and adaptation assistance;
- adaptation assistance fund administration;
- supplementarity provisions;
- executive board composition and responsibilities;
- process for designation of operational entities; and
- penalties for non-compliance.

6.3.2.3 Baselines

Credible project-based mechanisms under the Kyoto Protocol require the achieved net emission reduction (sink enhancement) to be determined.[69] The reduction is defined as the difference between what emissions (sequestration) would have been in the absence of the measure, the baseline, and actual emissions (sequestration). Thus, the baseline is an estimate of a situation that will never exist (Bohm, 1994; Jepma *et al.*, 1998; Kerr, 1998; Begg *et al.*, 1999).

Since the true baseline can never be observed, a baseline from which emission reductions are calculated may be estimated through reference to emissions from similar activities and technologies in the same country or other countries, or to actual emissions prior to project implementation.[70] Although this judgement is exercised through review by qualified, independent experts, possibly by stakeholders (such as environmental organizations), and by an entity with the final decision authority, the baseline will be an approximation of the counterfactual.[71] One way to reduce baseline uncertainty may be to limit the crediting period or to issue credits for only a fraction of the estimated emission reductions. However, this reduces the investors' interest in financing the projects.

Baseline determination requires a trade-off between the transaction costs of certification and the environmental costs of adverse selection, adjustments for increased emissions at other

[66] Therefore, some developing countries have proposed that a financial additionality requirement, which currently exists for the AIJ pilot phase and states that ODA funds should not be invested in such projects, should be extended to include the CDM. This view is not necessarily shared by all Parties.

[67] Estimates of the potential of the CDM are mounting (see, e.g., Austin *et al.*, 1998; Ellerman and Decaux, 1998; Zhang, 1999a), but the estimates are very sensitive to the rules applied for the CDM and the other Kyoto mechanisms.

[68] Contractual options to address this concern are available as well; the host government can insist on an option to acquire the right to future CERs from a project without cost at a specified future date, such as 2013.

[69] Note that the eligibility of sink enhancement projects under the CDM is still being negotiated.

[70] Harrison and Schatzki (2000) examine how baselines are established for several environmental and energy programmes in the USA.

[71] Parkinson *et al.* (2000) have estimated the range of uncertainty in estimates of emissions reduction because of the counterfactual nature of the baseline (based on a number of AIJ energy sector projects) to be between ±35% and ±60% depending on the project type.

Table 6.2: *Characteristics of activities implemented jointly projects*

Number of projects	94	Annex I countries: 68; non-Annex I countries: 26
Investors		Public sector: 61; private firms: 32
Project types	Renewable energy: 44%; energy efficiency: 38%; forestry or agriculture: 15%	
Project life (years)	16.5[a]	Range: 1 year to 60 years
Average emission reduction (tCO_{2eq})	1,658,320	Range: 13×10^6 to 57,467,271 (tCO_{2eq})
Average investment	US$6,298,065	Range: US$73,000 to US$130,000,000
Total investment	US$558,000,000[b]	
Average cost of emission reductions	Annex I: US$97/$tCO_{2eq}$; excluding "expensive" projects: US$26/$tCO_{2eq}$	
	Other: US$158/$tCO_{2eq}$; excluding "expensive" projects: US$9/$tCO_{2eq}$	

Source: Woerdman and van der Gaast, 1999.
[a]Average lifetime of projects considered.
[b]Total investment in all projects considered.

locations caused by the project (leakage), moral hazard, and changes over time in contextual economic, technological, and institutional conditions. Several options for baseline methodologies to try to deal with these trade-offs–including sectoral benchmarks, dynamic baselines, and selective eligibility of project types–are discussed in the literature (Chomitz, 1998; Hargrave *et al*., 1998; Jepma, 1999; Michaelowa and Dutschke, 1999a; NEDO, 2000). In addition, numerous IEA/OECD and other studies have been published on standardization of baselines for specific sectors.[72]

Also several options for baseline determination have been proposed in the literature (Chomitz, 1998; Hargrave *et al*., 1998; Jepma, 1999; Michaelowa and Dutschke, 1999a; NEDO, 2000). Several of these proposals try to deal with the issues of adjustment for increased emissions at other locations (leakage) and changes to the baseline over time.

Regardless of the method used to develop the project baseline, the partners involved in the project, excluding the JI host government, have an incentive to propose a baseline that yields as large a reduction as possible (Bohm, 1994; Wirl *et al.*, 1998).[73]

Baseline inflation would increase the number of credits created and raise the return to investors and/or the host firm or country. To minimize the risk of baseline inflation, an independent body with the authority to review certifications could be identified or created. In the case of the CDM the entity with the authority to make the final decision will be the Operating Entity, in accordance with the executive guidelines, or the Executive Board, or the CoP/MoP (Meeting of the Parties). In the case of JI the entity will be the host government.[74] The process adopted by the independent body would also determine the transaction costs involved in defining baselines.

6.3.2.4 Experience with Activities Implemented Jointly

Decision 1/CP5 of CoP1 in 1995 established a pilot phase for emissions reduction projects called Activities Implemented Jointly (AIJ). AIJ projects cannot create credits that can be used by Parties to meet commitments under the Convention or the Kyoto Protocol. This is a crucial difference between AIJ and JI or CDM projects. *Table 6.2* summarizes the characteristics of AIJ projects.

Dixon (1999) provides a comprehensive review of the experience with AIJ projects and the implications for JI and CDM projects, illustrating the valuable experiences gained in project baseline development and monitoring. However, several authors argue that AIJ projects may not be representative of

[72] For example, recent OECD/IEA baseline study references are: "Revised Framework for Baseline Guidelines", "Multi-Project Emission Baselines: Iron and Steel Case Study", "Multi-Project Emission Baselines: Final Cement Case Study", "Multi-Project Emission Baselines: Forestry Status Report", "Multi-Project Emission Baselines: Final Case Study on Energy Efficiency", Multi-Project Emission Baselines: Final Electricity Case Study", and "Case-Studies on Baselines for the Project-Based Mechanisms" (see http://www.oecd.org).

[73] Parties may not respond to these incentives, for instance, if such a response is incompatible with good business practices or would generate public criticism.

[74] The host government for JI projects has an incentive to minimize baseline inflation only if it faces effective penalties for non-compliance. Otherwise the benefits from the project could exceed the penalties because of non-compliance. If the penalties for non-compliance by Annex I Parties are weak or poorly enforced, JI projects could be subject to an international review process with authority to establish the quantity of ERUs issued and/or the ERUs could be incorporated into the liability provisions (see Section 6.3.5.3).

future JI and CDM projects (JIQ, 1998; Trexler, 1998; Woerdman and van der Gaast, 1999). Others suggest that AIJ projects provide limited guidance on how to establish baselines for emissions reduction or sequestration projects (Ellis, 1999; Lile *et al.*, 1999).

6.3.3 Direct International Transfers

The UNFCCC states that Annex II Parties (basically Annex I Parties except for the Parties in Central and Eastern Europe) shall provide new and additional financial resources, including the transfer of technology, needed by the developing country Parties to meet the agreed full incremental costs of implementing measures taken under the Convention and that are agreed between a developing country Party and the international entity or entities referred to in Article 11 of the Kyoto Protocol (UNFCCC, 1997, Article 11). So, the extent to which developing country Parties effectively implement their commitments under the Convention will depend on the effective implementation by developed country Parties of their commitments under the Convention related to financial resources and transfer of technology.

6.3.3.1 Financial Resources

Sustainable development requires increased investment, for which domestic and external financial resources are needed, particularly for developing countries (UN, 1992, Agenda 21, Chapter 34). In its Resolution 44/228 of 1989 giving a mandate to the convening of the UN Conference on Environment and Development (UNCED) in Rio de Janeiro, the UN General Assembly notes, *inter alia*: "that the largest part of current emission of pollutants into the environment originates in developed countries, and therefore recognizes that those countries have the main responsibility for combating such pollution", and that "new and additional financial resources will have to be channelled to developing countries in order to ensure their full participation in global efforts for environmental protection." Developed country Parties reaffirmed their commitments in the related provisions of the Kyoto Protocol. "The implementation of these existing commitments shall take into account the need for adequacy and predictability in the flow of funds and the importance of appropriate burden sharing among developed country Parties" (UNFCCC, 1997, Article 11).

Accordingly, Agenda 21 (UN, 1992, Chapter 33, especially its 15th Section) carries the consensus formulation that for developing countries: "ODA is a main source of external funding, and substantial new and additional funding for sustainable development and implementation of Agenda 21 will be required." In practice, however, there has been a clear trend of a continuing decline in ODA levels since UNCED. Total ODA dropped from 0.35% of total gross national product of the developed countries in 1991 to 0.29% in 1995, with further declines in 1996 and 1997 (OECD, 1998c). Some developed countries are contributing to solving the environmental problems that developing countries face with financial resources other than ODA. For instance, the Japanese government is implementing the Green Aid Plan that aims to achieve both economic development and environmental protection in developing countries in Asia. Most developing countries maintain that a sufficient level of financial resources is key to effective implementation of Agenda 21 and is a priority issue to be resolved to enable the implementation of the global consensus reached at the UNCED.

6.3.3.2 Technology Transfer

The transfer of environmentally sound technologies from developed to developing countries has come to be seen as a major element of the global strategies to achieve sustainable development and climate change mitigation. Article 4.5 and other relevant provisions of the UNFCCC (UNFCCC, 1992) clearly define the nature and scope of the technology transfer, which includes environmentally sound and economically viable technologies and know-how conducive to mitigating and adapting to climate change. Technology transfer implemented through the financial mechanism of the UNFCCC is to be "on a grant or concessional basis", on non-commercial terms. The Parties included in Annex II "shall take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies and know-how to other Parties, particularly developing country Parties, to enable them to implement the provisions of the Convention." Article 10, paragraph (c) of the Kyoto Protocol (UNFCCC, 1997) reiterated that all Parties shall: "co-operate in the promotion of effective modalities for the development, application and diffusion of, and take all practicable steps to promote, facilitate and finance, as appropriate, the transfer of, or access to, environmentally sound technologies, know-how, practices and processes pertinent to climate change, in particular to developing countries, including the formulation of polices and programmes for the effective transfer of environmentally sound technologies that are publicly owned or in the public domain and the creation of an enabling environment for the private sector, to promote and enhance the transfer of, and access to, environmentally sound technologies."

Three conditions have to be fulfilled for an effective transfer of technologies. First, the technology holder country must be willing to transfer the technology. Second, the technology must fit into the demand of the recipient country. Third, the transfer must be made at reasonable cost to the recipient. The IPCC Special Report on Technology Transfer (IPCC, 2000) identifies various important barriers that could impede environmental technology transfer, such as:

- lack of data, information, and knowledge, especially on "emerging" technologies;
- inadequate vision about and understanding of local needs and demands; and
- high transaction costs.

Some analysts argue with respect to the third item that the technology should be provided on favourable terms and therefore on non-commercial conditions, strictly separated from traditional technology transfers, and supported by government funding.

In fact, Agenda 21 (UN, 1992) states that "governments and international organizations should promote effective modalities for the access and transfer of environmentally sustainable technologies (ESTs) by means of activities, including the formulation of policies and programmes for the effective transfer of ESTs that are publicly owned or in the public domain." The major role of the government could be to supply EST research and develop funds to transfer publicly owned technology to developing countries. In this regard, the Commission on Sustainable Development, at its fifth session, concluded that: "a proportion of technology is held or owned by Governments and public institutions or results from publicly-funded research and development activities. The Government's control and influence over the technological knowledge produced in publicly-funded research and development institutions opens up a potential for the generation of publicly-owned technologies that could be made accessible to developing countries, and could be an important means for Governments to catalyze private sector technology transfer." In all countries the role of publicly funded R&D in the development of ESTs is significant. Through both policy and public funding, the public sector continues to be an important driver in the development of ESTs.

An additional role of the government is to make the legal provisions for the transfer of ESTs (including checking on abuse of restrictive business practices (Raekwon, 1997)). Good governance creates an enabling environment for private sector technology transfer within and across national boundaries. Although many ESTs are in common use and could be diffused through commercial channels, their spread is hampered by risks such as those arising from weak legal protection and inadequate regulation in developed and developing countries. However, many technologies that can mitigate emissions or contribute to adaptation to climate change have not yet been commercialized. Beyond an enabling environment, it will take extra efforts to enhance the transfer of those ESTs (IPCC, 2000). It should also be recognized that the effective transfer of ESTs requires substantial upgrading of the technological capacities in the developing countries (TERI, 1997) (see also Chapters 5 and 10).

6.3.4 Other Policies and Instruments

6.3.4.1 Regulatory Instruments

There are two ways to apply regulatory instruments internationally. One is to establish uniform standards for various products and processes for adoption by countries that participate in an international emission reduction agreement. There are several reasons why establishing uniform international standards for GHGs reduction is unlikely; for example, it is difficult to achieve agreement on the appropriate standards by affected interest groups in participating countries, and such an approach would limit the domestic policy choices of individual countries. The second way is to adopt fixed national emission levels (non-tradable emission quotas) for participating countries. These national emission limits can be considered performance standards that each country must meet through domestic action. This leads to inefficiency because marginal emission abatement costs differ among countries (IPCC, 1996, p. 404).

6.3.4.2 International and Harmonized (Domestic) Carbon Taxes

An international carbon tax, payable to an international agency, or domestic carbon taxes harmonized across countries, offer potentially cost-effective means of obtaining CO_2 reductions (IPCC, 1996, 11.2.2.2).[75] By associating a uniform price with carbon emissions in every country, only reductions that cost less than the tax will be implemented, assuming that the tax is implemented perfectly. To provide a common price signal in all countries, the new carbon tax may need to be differentiated across countries to account for existing domestic fuel taxes and revenue constraints (Hoel, 1993). Providing a common price signal to all sources subject to the tax also requires that all countries refrain from policies that directly or indirectly offset the tax (such as subsidies or regulations).

The revenue raised by an international carbon tax must be redistributed or used in an agreed manner. It is likely to be difficult to obtain an agreement on the share of the revenue that each country should receive. Harmonized domestic taxes avoid this difficulty by letting each country keep the revenue it collects. In practice, it is difficult also to achieve agreement on minimum levels of harmonized carbon and/or energy taxes high enough to impact carbon emissions significantly. Political pressures to combine tax proposals with exemptions for specific sectors contribute to this difficulty and, if accepted, reduce the efficiency and effectiveness of the tax.

International or harmonized taxes provide greater certainty about the likely costs of an emissions reduction programme, compared with a similarly designed international emissions trading programme (Toman *et al.*, 1999). This advantage can also be obtained by a hybrid policy, consisting of domestic emissions trading programmes coupled with a harmonized "trigger price", at which countries would sell additional permits domestically (McKibbin and Wilcoxen, 2000). The hybrid policy sets an upper bound on the marginal cost of abatement (like a carbon tax), but otherwise operates like an emissions trading programme. For a discussion of the pros and cons of such a hybrid system, see Sections 6.2.2.2 and 6.2.2.3.

The two major concerns about international price-based policies are the emissions levels, and the feasibility of international agreement:

[75] To improve efficiency a tax should be applied to as many sources of GHG emissions as feasible.

- The first concern is that price-based policies (taxes or hybrid systems) fail to guarantee particular emissions levels if it is not possible to adjust the tax rate frequently to achieve emission reductions in accordance with the set targets. If one assumes, for instance, that taxes are the only instrument used to fulfil the Kyoto Protocol commitments, in practice they most likely cannot guarantee that emissions commitments will be fulfilled either in the aggregate and/or for individual countries.
- The second concern is that an international agreement involving international or domestically harmonized taxes may be more difficult to negotiate than one involving emissions quotas. Wiener (1998) argues that the voluntary assent nature of international agreements means that nations must be made better off to participate, unlike domestic policies for which individuals can be coerced. While in theory international or domestically harmonized taxes can be combined with side payments to compensate losers, in practice such side payments are difficult to negotiate and tend to introduce dynamic inefficiencies since individual firms (and countries) do not bear the full social cost of their activities (Mestelman, 1982; Baumol and Oates, 1988; Kohn, 1992).[76]

Cooper (1998) takes the opposite position, arguing that taxes are the more feasible international approach. He argues that because of their rising contribution to global emissions, the participation of developing countries is essential for the long-term success of a programme to stabilize GHG concentrations in the atmosphere. He argues that it may be impossible to forge an agreement between rich and poor countries on the allocation of future quotas. Instead, "mutually agreed-upon actions", such as nationally collected emission taxes, are the logical alternative.

6.3.4.3 Standardization of Measurement Procedures

Several efforts are underway to standardize measurement procedures. For example, in the automotive industry, manufacturers from Europe, Japan, and the USA, jointly with respective governments, are trying to harmonize exhaust emission measurement methods for heavy-duty diesel vehicles (such as actual running conditions, measurement equipment, and procedures) by 2006. If successful, the automobile manufacturers' association intends to ask their respective governments to mandate the outcome.

Other international standards are set by the Organization for International Standardization (ISO). The ISO has begun to establish international Environmental Management standards in its 14000 series. The first standard among them (ISO 14001, Environmental Management Standard or EMS) was published in 1996 (ISO, 1996).

ISO environmental standards are framework standards and do not set any performance standards. They are flexible to facilitate application by a wide variety of organizations throughout the world. An organization can select any environmental aspects (such as emissions to air and/or water, ozone depletion, climate change, etc.) it considers important for its activities. This means that the standards may be effective as tools to cope with global warming if they are utilized for that purpose. In December 1997, the Climate Technology Initiative (CTI) of the OECD and the ISO issued a Joint Statement concerning the potential contribution of international standards to climate change (ISO, 1998a). In 1998, ISO established a Climate Technology Task Force to review the application of the ISO 14000 series to climate change (ISO, 1998b).

In January 2000, ISO's Technical Management Board established an Ad Hoc Group on Climate Change (AHGCC) to develop a comprehensive ISO strategy for climate change. While ISO has not ratified a climate change strategy, the AHGCC has identified several areas in which the development and use of ISO standards may help facilitate implementation of the UNFCCC and its Kyoto Protocol, including (among others):
- codes of practice and guidelines for accreditation bodies and operational entities;
- CDM project validation, verification, and/or certification standards; and
- GHG measurement, monitoring, and reporting standards.

6.3.4.4 International Voluntary Agreements with Industry

Several voluntary initiatives that have an international impact have been identified. For instance, various multinational firms have undertaken voluntary actions to cope with climate change, including setting up emissions trading systems and engaging in trades.

A VA was concluded in July 1998 between the EC and the European Automobile Manufactures Association (ACEA). The EC subsequently negotiated a similar agreement with Japanese and Korean car manufacturers. The agreements are expected to reduce CO_2 emissions from new cars in 2008 by 25% below the 1995 level. Implementation is contingent on several preconditions, such as fuel quality improvement. The EC has been engaged in discussions with European industry associations regarding a possible VA on energy efficiency in televisions and videocassette recorders (EEA, 1997).

The United Nations Environment Program (UNEP) Statement by Financial Institutions on the Environment and Sustainable Development and the UNEP Insurance Initiative may be clas-

[76] Unlike side payments on a lump-sum basis, which remain efficient, side payments and/or subsidies determined by emission levels are not (because then the environmental impact of the original policy measure would be reduced). In the case of a tradable quota regime, the side payments take the form of more generous quota allocations, which are efficient, unless they are tied to emission levels.

sified as international VAs. Banks and insurance companies that sign these initiatives have to pay attention to environmental protection in their management and in their product selections and operations. These initiatives are not binding and no monitoring of conduct has been carried out. In addition, the territorial distribution of the signing banks and insurance companies is uneven; participation from developing countries and the USA is rare, and no Japanese banks signed the Financial Institutions Initiative.

Some domestic VAs may evolve as *de facto* international VAs. The Energy Star programme began in 1992 as a voluntary partnership between the US DOE, the US Environmental Protection Agency, product manufacturers, and others. Partners promote energy efficient products by labelling them with the Energy Star logo and educating consumers about the benefits of energy efficiency.[77] A similar programme has started in Japan, and several European governments and manufacturers are considering setting up similar programmes. No analyses of the costs and impacts of these programmes are available.

6.3.5 International Climate Change Agreements: Participation, Compliance, and Liability

6.3.5.1 Participation

One of the concerns in the economics literature on environmental agreements (including the UNFCCC and Kyoto Protocol) has been with increasing participation. The most obvious way in which international agreements seek to increase participation is by means of a minimum participation clause. This is an article that specifies the agreement will not be binding on any of its Parties until a large enough number of countries–and, sometimes, particular countries or types of countries–have ratified the agreement. The minimum participation clause effectively makes the obligations of each of its signatories a (non-linear) function of the total number of signatories.

The minimum participation clause can serve as a strategic device, but this need not always be the case. Suppose that the minimum participation level is given as k^+. Then, if the actual number of signatories is k, and $k < k^+ - 1$, accession by a non-signatory neither costs this country anything nor confers upon it any advantage. This is because the agreement would not yet be binding on this country. However, if $k = k^+ - 1$, then accession has a non-marginal effect on the environmental problem, for the accession will mean that *all* of the k^+ countries must undertake the measures prescribed by the treaty. One way to sustain full co-operation would be to set k^+ equal to the total number of countries affected by an environmental problem (i.e., all countries), while ensuring that every potentially participating country is better off with the agreement than without it. Obviously, the threat not to undertake any abatement for a smaller value of k can be an important incentive for countries that consider joining the agreement to actually do so (because they believe that free-riding doesn't pay). It is therefore extremely important that this threat be credible. However, in the vast majority of cases it will not be (Hoel, 1993; Carraro and Siniscalco, 1993; Barrett, 1994).

More importantly, the actual number of Parties to an agreement usually exceeds the minimum participation level, which is another reason why the above threat mechanism cannot be used to deter free-riding. The minimum participation level clause may rather serve as a co-ordinating device than as an actual incentive to join the agreement.

The point, however, is that while agreements must offer some alternative means for deterring free-riding, often they do not. The literature on international environmental agreements therefore predicts that participation will be incomplete, and it often is. One of the few agreements that disproves this general rule is the 1987 Montreal Protocol on Substances that deplete the ozone layer (UNEP, 1987; revised and amended in 1990 and 1992). The revised Protocol contains provisions that control trade between Parties and non-Parties to the regime. Coupled with the financial resources available to developing countries Parties that are not available to non-Parties, the Party–non-Party trade provisions are widely cited as a major factor in explaining the near universal participation in the ozone regime (Rowlands, 1995). See also Chapter 10 for a further discussion on participation in international regimes.

6.3.5.2 Compliance

The bulk of environmental agreements cannot operate the financial "carrots" and/or trade restriction "sticks" illustrated by the ozone regime (Wiser, 1999a). The key question therefore becomes: how can compliance by all Parties be secured, given the consensual basis of international law and the reluctance of Parties to endow international bodies with legal authority to enforce the international commitments Parties have (freely) undertaken against them? The UNFCCC has near universal participation based on the traditional consensual approach buttressed by provisions that aim to facilitate developing country participation through the provision of financial and technological resources. The general nature of the commitments contained in the Convention would, in any case, prove difficult to enforce. These factors explain why Parties have not endowed the supreme body of the Convention, the CoP, with the authority to impose legally binding consequences on a Party in the event of non-compliance. Thus at present, no legal body exists to enforce compliance in the climate change context.

The quantified, legally binding commitments of the Kyoto Protocol pose a different challenge (Werksman, 1998). In the period after Kyoto, the majority of Parties signalled a clear desire to move towards a compliance system based on legally binding consequences, even though the compliance provisions of the Kyoto Protocol provide that legally binding conse-

[77] See http://www.epa.gov/appdstar/estar/

quences can only be adopted by means of a formal amendment to the Protocol. Be that as it may, UNFCCC negotiations on the institutions and procedures of a compliance system for the Protocol are well advanced.

Various suggestions have been put forward in the literature and by Parties for the kind of legally binding consequences deemed appropriate in the climate regime (Corfee Morlot, 1998; Wiser and Goldberg, 2000). These include the following (Grubb *et al.*, 1998; UNFCCC, 2000):

- allowing a "true-up" or grace period with opportunity to buy quotas;
- payment into a national or international compliance fund that would invest in quotas;
- issuing cautions and/or reports to motivate public pressure;
- suspending treaty privileges (such as voting or the right to nominate members for office);
- exclusion from access to the Kyoto mechanisms; and
- financial penalties and implementing trade sanctions.

As a result of the difficulties in agreeing any of these consequences, and their future enforceability, more attention has been paid to policy tools that prevent non-compliance. Again, suggestions in the literature and from the Parties focused on ensuring that emissions trading must be transparent at both the Party and entity level[78], and that emissions data, such as inventories, are publicly available. The idea being that Parties and/or firms may fear the reputation consequences of being identified as polluters. Furthermore, trading could be authorized only for eligible Parties or entities, namely those meeting some minimum standards on monitoring and reporting. Non-eligible Parties and/or entities could be suspended from the trading system.

Parties also could require that insurance be obtained for traded tonnes of emissions reductions. An extra quota reserve held for the premium payer could then be claimed if the traded tonnes fail to be verified as emission reductions. A similar proposal is to establish a "true-up" period or grace period (of some several months or years) after 2012; a party that is able to come into compliance at the end of this true-up period would be deemed to have complied with the agreement. Several other possibilities have been mentioned to enforce compliance with the Kyoto targets in a situation with IET.

6.3.5.3 Liability

Liability provisions prescribe how quotas transferred by a party that subsequently is not in compliance with its emissions limitation commitment are treated. Since the developing country hosts of CDM projects do not have emissions limitation commitments, this is not an issue for CERs once they have been certified and issued by the operational entity or the Executive Board. However, this does not deal with the question of what happens if the certification has not been undertaken to acceptable standards or if there are other significant irregularities in issuance procedures. Since both JI and IET involve only Parties with emissions limitation commitments, treatment of quotas traded using these mechanisms must be addressed if the issuer does not achieve compliance.

With regard to JI, Article 6.4 of the Kyoto Protocol specifies that if compliance by an Annex I country is questioned under Article 8, any ERUs acquired from that country cannot be used to meet the buyer's commitments under Article 3, until the question of non-compliance by the originating country is satisfactorily resolved (UNFCCC, 1997).

If the ERUs issued for JI projects are determined by an international review process, they reflect corresponding reductions of the host country's emissions and hence do not contribute to its non-compliance. However, if the decision on the quantity of ERUs issued is left to the host government and the penalties for non-compliance are weak or not effectively enforced, JI projects could contribute to non-compliance by the host country. Since any ERUs transferred must be deducted from the party's AA, they could be made subject to the liability provisions for IET.

Article 17 does not include any provisions to deal with quotas that have been transferred by a country that subsequently fails to meet its emissions limitation commitment. A number of options and variants have been proposed in the literature (Goldberg *et al.*, 1998; Grubb *et al.*, 1998; Haites, 1998; Baron, 1999; Zhang, 1999b). The proposals reflect various strategies, including seller and (its opposite) buyer liability, eligibility requirements for buyer and sellers, limits on the quantity of quota that can be sold, limiting sales to quantities surplus to estimated or actual compliance needs, or restoration of default. These approaches can be grouped into those that aim to prevent or limit the risk of non-compliance, and those designed to provide sufficient deterrence (either requiring the defaulting party to face the regimes' non-compliance system or else harnessing the market to discount quotas from those Parties considered to be most at risk).

These liability proposals differ in terms of their environmental effectiveness, impact on compliance costs of Annex I Parties, and market liquidity. The proposals can change the ratio of domestic reductions to purchased quotas used for compliance and the mix of quotas purchased. In this way they can change the distribution of costs across countries, including non-Annex I countries through the volume of CDM activity. In policy terms, it is likely that the most effective strategy would aim to combine one or more of them. Details of how this may be undertaken, as well as on how many of the proposals would be implemented in practice, are currently subject to international negotiations.[79]

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[78] Given the wording of Article 17, the participation of legal entities in IET based on Article 17 would require an explicit decision by CoP/MoP (see also Section 6.3.1).

[79] For example, whether under a buyer liability system transferred quotas would be invalidated pro rata or in reverse chronological order.

6.4 Interrelations Between International and National Policies, Measures, and Instruments

6.4.1 Relationship Between Domestic Policies and Kyoto Mechanisms

It is important to consider ways in which international and national (domestic) policy instruments are likely to complement or conflict with one another in achieving GHG emissions reduction commitments at least cost. A substantial number of economic models suggest that use of the Kyoto mechanisms, established by Articles 6, 12, and 17 of the Kyoto Protocol (see Sections 6.3.1 and 6.3.2), combined with efficient domestic policies could significantly reduce the cost of meeting the emissions limitation commitments in the Protocol.[80] The results of these models rely on assumptions of perfect foresight or certainty over future levels of emissions and on fully efficient domestic mitigation policies in Annex I Parties. They also assume that developing countries will respond to the market signal given by the international market of CERs and generate CDM projects accordingly.[81] Moreover, these models implicitly assume that national economies are operating within an efficient market framework. However, when an inefficient market framework is assumed the conclusions may differ. This is an area in which further research is necessary.

Articles 6 and 12 of the Kyoto Protocol enable governments and entities of Annex I countries to support JI projects in other Annex I countries and CDM projects in non-Annex I countries, respectively, in return for emissions credits. Several countries have suggested the participation of legal entities in IET, although Article 17 (on IET) does not mention the participation of entities in IET other than Parties (see Australia *et al*. (1998) and United Kingdom of Great Britain and Northern Ireland (1998)).

The following discussion assumes that any supplementarity provisions are not binding.[82] In addition, MAC refers here to the marginal social abatement costs. Also, in this discussion it is assumed that the initial market is perfect and then how various factors influence this is assessed.

If IET under Article 17 is limited to Annex I governments, they would need to trade AAUs or introduce a domestic emissions trading scheme to equate their national MACs. Views differ as to whether national governments have the information to equate the national MACs. Experimental evidence indicates that governments have the necessary incentive when trading with other governments.[83] If both Annex I governments and legal entities are allowed to engage in IET under Article 17, this difference of views becomes academic as long as the domestic policies allow the legal entities to use the three Kyoto mechanisms as part of their compliance strategy. Government participation in the Kyoto mechanisms changes the AAs available for emissions by domestic sources.

For entities to equalize their MACs there must exist either a fully comprehensive domestic taxation system, which reflects the international price of AAUs, or open access to the international emissions market for sources of emissions and entities covered by domestic policies. In theory, several domestic policy regimes can be envisioned that would allow entities in Annex I countries to equalize their MAC so as to minimize the total cost of reduction. The implications for different types of domestic policy instruments are as follows (Dutschke and Michaelowa, 1998; Hahn and Stavins, 1999):[84]

- *Domestic tradable permits*. The domestic tradable permit programme must cover virtually all emissions sources, the cap must be set equal to the national AA after trading by the government, and the participants must be allowed to engage in international exchanges using the Kyoto mechanisms.[85] Participants would be allowed to use CERs and ERUs from CDM and JI projects towards compliance with their domestic obligations. The country could also host JI projects. Participants could also buy or sell AAUs under Article 17 if participation by legal entities was allowed.[86]
- *Domestic emissions and/or carbon tax*. The domestic emissions and/or carbon tax must cover virtually all emissions sources, and the tax must be set equal to or

[80] See Chapter 8 and Bernstein *et al.* (1999), Bollen *et al.* (1999), Cooper *et al.* (1999), Jacoby and Wing (1999), Kainuma *et al.* (1999), Kurosawa, *et al.* (1999), Manne and Richels (1999), McKibbin *et al.* (1999), Nordhaus and Boyer (1999), Tol (1999), Tulpulé *et al.* (1999), and Weyant and Hill (1999) for estimates of the cost savings resulting from various international quota trading arrangements. All the models assume efficient domestic policies, and international trading, within each region. The models typically have between four and 20 regions.

[81] See Baron and Lanza (2000) for a review of modelling results on the contribution of the Kyoto mechanisms.

[82] See Section 6.3.1 for a discussion of supplementarity.

[83] An experiment with emissions trading among government teams representing four Nordic countries revealed a trading efficiency of 97% (Bohm, 1997). Thus, their social MACs almost exactly equated at the national level.

[84] To explore the conditions under which different domestic policies can minimize costs with the aid of the Kyoto mechanisms, Hahn and Stavins (1999) examine pairs of countries with different combinations of domestic policies. The discussion here presumes that all Annex I Parties wish to implement domestic policies that enable all sources to equalize their MACs.

[85] A similar system could be based on voluntary agreements in which sources are allowed to trade emission reductions in the form of AAUs, ERUs, or CERs.

[86] The permits used in the domestic tradable permit system could be AAUs. Alternatively, the domestic permits could be freely exchangeable for AAUs.

less than the national marginal cost of abatement after trading by the government. Entities receive tax credits for CERs and ERUs, and for AAUs if participation by legal entities is allowed under Article 17. The country could also host JI projects.[87]

- *Non-tradable permits*. Virtually all sources are covered by non-tradable emissions limits, which allow the use of quotas to achieve compliance. The total emissions allowed under the permits must be equal to or less than national AAs after trading by the government. Entities could use purchased CERs and ERUs–and AAUs if participation by legal entities is allowed under Article 17–towards compliance with their emissions limits. The country could also host JI projects to reduce emissions below the emissions limits or to enhance sinks.

If sources are subject to regulations, design or performance standards, VAs, or taxes and at the same time there is no permit allocated to the source, and CERs, ERUs, or AAUs cannot be used for compliance, entities might still be allowed to trade them on the international market, provided that the volume sold does not exceed the volume of quotas acquired. Such domestic policies are unlikely to equate MACs across sources and so will not result in the lowest cost of compliance with the national emissions limitation commitment.

In practice, the combination of domestic policies and Kyoto mechanisms necessary to achieve cost-effectiveness may not be implemented for at least two reasons. First, use of the Kyoto mechanisms may be restricted in some countries, either because supplementarity restrictions are binding or because a national government that imposes an emissions tax may limit the use of the mechanisms towards compliance with tax liabilities to protect its revenue.

Second, it is difficult to cover all sources and relevant sinks with policies that provide an incentive to implement measures that equate MACs. Some sources are small and are excluded for administrative reasons. Other sources, such as methane emissions by livestock, are difficult to include in a trading or tax regime. Thus, the overall cost-effectiveness of the system will fall short of the theoretical ideal.

When part of the GHG emissions reduction needed to realize the Kyoto commitments offers net economic benefits to the national economy, the role of the Kyoto mechanisms changes significantly. Relative to a theoretical scheme of complete and perfect trading, a purely national mitigation strategy would still give rise to inefficiencies for individual countries or sources, as a result of differentials in MACs. However, the advantages that could be obtained from eliminating such inefficiencies through international mechanisms are more limited because of principal-agent problems.

[87] Only sources or sinks not subject to the tax are likely to be approved as JI projects, to reduce the risk of double counting.

Thus, if access to the international mechanisms is limited to governments, the Kyoto mechanisms are likely to be used only to reduce positive marginal domestic abatement costs. And, since measures with positive costs under a regime with restrictions make up only a fraction of total mitigation under an efficient domestic policy, the quantitative significance of the Kyoto mechanisms is greatly reduced. If access to the Kyoto mechanisms is given to individual sources, there arises the potential for a second principal-agent problem in that individual entities may mitigate in ways that minimize private costs but fail to minimize social costs in the national economy. In this case, both international efficiency and domestic efficiency are jeopardized.

6.4.2 Conflicts with International Environmental Regulation and Trade Law

Compatibility of environmental protection with free trade and/or investment has been important in both the environmental and trade fields. The Committee on Trade and Environment of the WTO has under discussion the relationships between the provisions of the multilateral trading system and trade measures for environmental purposes, including those pursuant to multilateral environmental agreements (MEAs). Also under discussion are the relationships between environmental policies and measures with significant trade effects and the provisions of the multilateral trading system. Some analysts suggest that the WTO is not an appropriate forum to resolve these questions and propose the establishment of a multilateral environmental organization for this purpose (Esty, 1994).

The UNFCCC is one of more than 200 multilateral and bilateral international environmental agreements (MEAs) whose compatibility with free trade and investment is debated (UNEP, 1983, 1991). More than 20 MEAs incorporate explicit trade measures.[88] Other MEAs address the need to co-ordinate restrictions on conduct taken in compliance with obligations they impose and the expanding regime of trade and investment law under the WTO/GATT umbrella.[89] UNFCCC Article 3.5 (UNFCCC, 1992), following GATT Article XX, stipulates that "Parties shall co-operate to promote a supportive and open international economic system that would lead to

[88] See Ward and Black (2000, p. 122). Some MEAs, like the 1973 Convention on International Trade in Endangered Species (CITES, 1973), the 1989 Basel Convention on the Control of Transboundary Movements of Hazardous Waste (UNEP, 1989), or the 1987 Montreal Protocol on Substances that Deplete the Ozone Layer Articles, 4.1, 4.2, and 4.3, restrict trade in polluting products or products that contain controlled substances (UNEP, 1987). Some, like Montreal Protocol Article 4.4, propose trade sanctions, but these are, however, not implemented, even on products manufactured with polluting substances.

[89] Agenda 21 (UN, 1992), Chapters 2.3, 2.11, 2.20 and 17; Principles 11 and 12 of the Rio Convention; Convention on Biodiversity, Article 22.1.

sustainable economic growth and development in all Parties ... Measures taken to combat climate change, including unilateral ones, should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade."

There are no presently cited cases of trade claims against measures enacted in widely subscribed MEAs like the CITES or the Montreal Protocol. Neither the UNFCCC nor the Kyoto Protocol now provides for specific trade measures. The debate over conflicts between trade and MEAs stems from the prospect that trade-related measures might be enacted to limit trade in polluting products and in endangered species, or trade in goods created by means of polluting processes and production methods (PPMs). MEAs could also require general or specific trade measures to sanction non-Parties to the MEA or non-compliant MEA members.

IET under Article 17 of the Kyoto Protocol has raised questions of WTO compatibility. Early analysis concludes that the rules governing the transfer and mutual recognition of allowances are not covered by WTO because they are neither products nor services (Werksman, 1999).[90] However, several domestic policies and measures that may be taken in conjunction with the Kyoto Protocol might be considered to pose WTO problems, such as excessively restricting trade regulations, GATT-inconsistent border charges, or illegal subsidies.[91]

National programmes of permit distribution for emissions trading (see Section 6.2.2.3) or national environmental aid (subsidies) might benefit domestic firms or sectors over importers or foreign competitors (Black *et al.*, 2000).[92] In addition, a Party or group of Parties (as part of the national implementation programmes) might apply taxes or environmental policies and measures in a way that arguably discriminates against WTO trade partners. Environmental regulations, taxes, or voluntary measures could be challenged as indirect forms of protection that fall disproportionately on imported products. Recent cases suggest more cases could be argued under the agreement on Technical Barriers to Trade (TBT) rather than GATT.[93]

Trade-related environmental measures traditionally pose problems for the multilateral trading regime. Considerations of sovereignty favour the autonomy of WTO Parties to set health or environmental standards for all products, domestic or imported, consumed in their national territories. Each country has broad discretion to introduce its own policies and measures, including energy efficiency standards and import restrictions, to protect its environment and/or its people's health, subject to GATT Article 3 (national treatment). However, more debatable is whether GATT permits a government to place restrictions or bans on the import of goods or services, themselves not dangerous or polluting, that are produced outside its borders through PPMs that do not meet its national environmental regulations or standards. PPM issues may be characterized as "clean products produced through dirty processes". As MEAs increasingly utilize trade measures to prevent non-members from free-riding, the consistency of such trade measures with the relevant GATT articles (Article XX, in particular) has been questioned when they are based on the lack of corresponding PPM requirements in the exporting countries (Murase, 1995, 1996). At present, the relation between WTO-compatible environmental measures and MEAs remains unsettled. It is also unclear whether WTO law is neutral in its treatment of alternative trade-related measures (e.g., standards, taxes, and subsidies).

Prior to 1995, when GATT 1994 replaced GATT 1947 under the WTO agreement, six panel reports involved environmental issues related to trade measures under Article XX (Ahn, 1999). The Appellate Body under the revised WTO dispute settlement system has since decided two further cases.[94] While none of these disputes challenged the environmental objectives pur-

[90] Black *et al.* (2000) note that if emissions trading is treated as a financial service, there is no clear policy reason to exclude non-Parties to the Kyoto Protocol from trading in these markets.

[91] For example, a Party might impose equivalent product-specific energy-efficiency standards on domestic and imported refrigerators or automobiles. Or a Party might ban the domestic production and import of rice grown under methane intensive cultivation methods or of wood harvested under non-sustainable forestry practices. Alternatively, a party might impose a tax on the carbon content of domestic and imported fuels or the carbon consumed in the production of national and imported products. Finally, a Party might impose countervailing duties against imports from nations that do not force the internalization of GHG emissions costs on national producers.

[92] National energy policies have long been replete with distortionary subsidies (Black *et al.*, 2000, pp. 90–98). However, since even subsidies that encourage production below marginal factor costs have rarely been GATT challenged, it is unlikely that national policies that fail to internalize full environmental costs will be GATT illegal, unless they explicitly discriminate between national production and imports. Energy efficiency subsidies to internalize environmental benefits are, in principle, permissible under the GATT subsidies code.

[93] For example, when the EC concluded a voluntary agreement with ACEA to reduce CO_2 emissions from automobiles in February 1999, the Commission asked non-EU automobile manufactures to conclude the same kind of agreements, fearing that the European car manufacturers might lose international competitiveness. As a result, in October 1999, the Japanese Automobile Manufacturing Association's voluntary commitment to follow the same standards was approved by the EU. When the Japanese government enacted an amendment to strengthen fuel efficiencies of automobiles, both European and American governments expressed their concern, through formal TBT procedure, that it would become an invisible trade barrier for automobile export. Also, when the EC intended to propose a Directive on Waste Electrical and Electronic Equipment, both the US and Japanese governments expressed the same concern.

[94] Perkins (1999); see also United States -Standards for Reformulated and Conventional Gasoline (World Trade Organization, 1996).

sued by the governments concerned, all rulings found that the contested trade restrictions were in some respect discriminatory or unnecessarily trade restrictive. However, more recent rulings, including those of the Appellate Body, have narrowed or rejected earlier panel interpretations that had held PPMs either *per se* inconsistent with the intent of GATT or highly restricted by the terms of Article XX.

The GATT Panel rulings in the Tuna–Dolphin I dispute read Articles XXb and XXg so as to preclude provisional justification for extraterritorial PPMs as inherently arbitrary measures destructive to the system of international trade.[95] The panel in the Shrimp–Turtle dispute also explicitly held that the US shrimp embargo belonged to the class of measures (PPMs) that threatened the multilateral trading system and therefore violated the terms of the Chapeau of Article XX. However, the WTO Appellate Body overruled the Panel's view in the Shrimp–Turtle case. The WTO indicated implicitly that it does not categorically disallow the use of extrajurisdictional PPMs.[96] Although the import restrictions in question applied to shrimp harvesting practices and not to any characteristic of the shrimps themselves, the Appellate Body treated the measure as provisionally justifiable. It considered the legality of the specific restrictions, which were held to be invalid under the prohibition of the Chapeau of Article XX of discriminatory and arbitrary measures. The US embargo was ruled overly broad, its enforcement inflexible in considering the conservation effects of other nations' shrimping practices, disparate in its treatment of other nations, deficient in due process, and put into effect without sufficient good-faith efforts to secure wider multilateral acceptance of its exclusionary programme (Berger, 1999).

Although as yet there is no universally accepted interpretation of the Shrimp–Turtle Appellate Body decision, some analysts suggest the holding implies PPMs no longer violate WTO by their very nature (Ahn, 1999). Others argue such a conclusion is premature legally or has been insufficiently debated and tested in the scientific literature (Jackson, 2000). In either case, the ruling did not refer to important questions relevant to the interaction of WTO and the UNFCCC and/or Kyoto Protocol. It is unclear whether national PPMs need only be enacted by Parties to an MEA in their compliance programmes, or whether each particular PPM, its mode of application, and/or its sanction scheme are the subjects of multilateral accord. Nor is it certain how widely the multilateral agreement that supports the PPM must be subscribed to make it WTO compatible.[97]

Parties to MEAs might base national climate programmes on pollution taxes rather than product or PPM standards. WTO law does allow compensating charges or border adjustments to similar imported products to equalize the tax burden on domestic production. While direct taxes (wages, incomes) may not be compensated on imports or refunded on exports, certain indirect taxes, such as sales taxes or excises, may be adjusted at the border.[98] Indirect environmental taxes levied on a locally polluting product like imported fuel or gas guzzling automobiles, as long as not in excess of charges imposed on like domestic products, would be WTO consistent. Analogous indirect taxes, equal to domestic taxes, imposed on non-locally polluting imports produced through foreign process and production methods that were environmentally damaging have been approved in the GATT dispute settlement process.[99]

Nevertheless, some border charges on products manufactured through GHG-intensive PPMs might be WTO inconsistent. Although specific taxes on final products (e.g., fuels) and on "goods physically incorporated" into final products (e.g., a feedstock or catalyst) may be adjusted at the border, so-called hidden taxes on inputs, such as transport, machinery, advertising, or energy entirely consumed during production, have not been legally adjustable. Current practice is not fully symmetrical in its treatment of regulatory standards and taxes as environmental instruments.[100]

[95] United States–Restrictions on Imports of Tuna (World Trade Organization, 1994).

[96] See Shrimp–Turtle decision, paragraphs 121 and 187b (World Trade Organization, 1999); see also Perkins (1999, p. 119).

[97] Nor is there yet guidance whether trade restrictions could be enforced against a UNFCCC party with differentiated responsibilities under the MEA, even if WTO-legal restrictions against imports from non-Annex I Parties would confuse the meaning of "differentiated responsibilities".

[98] Economists have long noted the lack of precision of the categories direct and indirect taxes, as well as the dependence of the ability to pass on the incidence of taxes to consumers (indirect taxes) on market structure. However, the terms continue to be applied with reasonable ease in legal practice (Demaret and Stewardson, 1994, pp. 14–16).

[99] In the Superfund Tax case, US border charges on certain waste creating feedstock chemicals used as inputs in the processing of imported chemical derivative products were ruled to be legal. These border charges, equal to taxes imposed on similar US feedstock, were held valid even though there was no transboundary damage outside the nation of origin (World Trade Organization, 1988). A border tax on shrimp caught with turtle-unsafe methods and similar to a domestic tax on such products would seem to fall under this rule. Products that have been produced through differential production methods, like products that have different environmental qualities in themselves, have usually been considered to be not "like products" and therefore allowable objects of differential, non-discriminatory taxes (Demaret and Stewardson, 1994, pp. 34–41).

[100] A limited amendment to the treatment of energy taxes was made in the Uruguay 1994 Agreement on Subsidies and Countervailing Measures. Border adjustments were allowed for those nations that still imposed cumulative prior-stage indirect taxes on "energy, fuels, and oil used in the production process". This exception to the hidden tax rule was intended to cover only a limited set of nations (Demaret and Stewardson, 1994, pp. 29–30).

6.4.3 International Co-ordination of Policy Packages

When developing domestic policies to meet their emissions limitation commitments under the Kyoto Protocol, some Annex I Parties may wish, or be under pressure, to impose less stringent obligations on some industries to improve their competitiveness. The sensitivity of industry location to the stringency of environmental regulation is called "ecological dumping". International co-ordination of environmental policies may be needed to reach an economically efficient outcome in which it is impossible to make one country better off without making at least one other country worse off.

Under certain ideal conditions (e.g., perfect competition in all markets) there is theoretically no need for international policy co-ordination (Oates and Schwab, 1988). However, such conditions do not hold if there is imperfect competition in goods markets or unemployment (Rauscher, 1991, 1994; Barrett, 1994; Kennedy, 1994; A. Ulph, 1994; D. Ulph, 1994). If, and to what extent, international differences in environmental regulation have trade or even relocation implications obviously depends on a host of factors. These include country size, availability of alternatives, relative resource endowment, mobility of production factors, competition level, scope for innovation, possibility of border-tax adjustment, chances of retaliation, and redistribution of environmental tax revenues (OECD, 1996a).

Although it is clear that many factors affect the relationship between the stringency of pollution control policies (if implemented unilaterally) and net exports, some authors have carried out rather straightforward empirical tests on the relationship between the two variables. Han and Braden (1996) examined 19 US manufacturing industries between 1973 and 1990 with the help of regression analysis. They found the relationship between pollution abatement costs and net exports to be negative in most of the sample period, but diminishing over time (with elasticities close to zero in many industries). Van Beers and Van den Bergh (1997), using a gravity model of international trade and two measures of environmental stringency, did not find a significant relationship between environmental stringency and total exports for the "dirty" industries. However, when they focused on the non-resource based, and therefore more "mobile", industries only this relationship was significant.

Early empirical research on the impact of environmental policy on trade found little evidence of a measurable relationship, partly because of low environmental taxes and partly through data and statistical limitations. Therefore, many studies have concentrated on simulations of environmental tax regimes. From a survey of these studies, IPCC's SAR (IPCC, 1996) concluded that estimates of the effects of environmental policies (notably carbon taxes) on trade vary wildly, depending on model parameters (such as energy demand elasticities and assumptions regarding the substitutability of traded goods) and the policy scenario examined (extent of reduction in emissions and extent of international co-ordination).

Various partial equilibrium models have been designed to analyze ecological dumping, many using static or dynamic game theory. Early analyses used a Cournot setting, which models long-run competition among firms as a series of strategic capacity or output choices. The general conclusion from these early models is that the optimal tax (or any comparable domestic environmental policy instrument) would be set below marginal damage. As a consequence, environmental policies are designed to try to protect domestic industries. If producers collude, however, the incentive for governments to engage in ecological dumping is reduced (Ulph, 1993).

The ecological dumping conclusion could change completely if governments act strategically in setting taxes, and if there is Bertrand competition (firms compete by choosing the price to charge, rather than the quantity to produce) instead of Cournot competition (Eaton and Grossman, 1986; Barrett, 1994; Conrad, 1996; Ulph, 1996). If, however, producers act strategically or can collude, then the outcome in terms of ecological dumping is not straightforward. Quantity-based environmental regulation, if implemented unilaterally in a duopolistic case with a domestic and foreign supplier, might actually benefit domestic firms at the cost of domestic consumers (Kooiman, 1998). If both governments and producers act strategically, again, the incentive for governments to distort the environmental policy is less than when only governments acted strategically, so that the Bertrand outcome can be similar to the Cournot outcome (Ulph, 1996).

Ecological dumping also has been analyzed with the help of general equilibrium models of international trade involving externalities (Rauscher, 1994). It was shown that in a second-best world for several market structures–monopoly power of the exposed sector or oligopoly on an outside market (Elbers and Withagen, 1999)–ecological dumping might not (always) be beneficial from a welfare point of view. This is contrary to the conclusions of some of the earlier partial equilibrium models,

The most interesting case for analyzing policy co-ordination needs is that in which national commitments have been decided internationally, but individual Parties may, but need not, co-ordinate their national policies to fulfil their commitments. This would be the Kyoto Protocol case, after ratification. Hoel (1997) has addressed this case and argues that governments may tend to subsidize indirectly particular imperfectly competitive industries selling on the international market. To prevent this from happening, an argument can be made in favour of policy co-ordination, which is possible but not required in the Kyoto Protocol, except insofar as the Kyoto mechanisms are concerned.[101]

6.4.4 Equity, Participation, and International Policy Instruments

The participation of developing countries and EITs in the UNFCCC is important, since these countries are both large future emitters of carbon, and sources and potential sources of low-cost abatement investments (McKibbin and Wilcoxen, 2000). Since the participation of regions with low marginal abatement costs may be critical for aggregate cost and emissions reduction, encouraging their participation may require a serious consideration of the equity implication of that policy (Morrisette and Plantinga, 1991). Unlike efficiency, there is no universal consensus definition of equity by which policy instruments can be evaluated. Recent research on equity, however, analyzed the welfare impacts of climate policy alternatives to understand the participation incentives (for different countries and regions) of various policy instruments (Bohm and Larsen, 1994; Edmonds *et al*., 1995; Rose *et al*., 1998).

The types and structures of mechanisms adopted (such as uniform taxes, tradable quota, or individual non-tradable targets) affect the scope and timing of participation in some predictable ways (Edmonds *et al*., 1995). For example, individual non-tradable targets based on the stabilization of national emissions would shift more than 80% of aggregate costs to non-OECD regions by 2020, making it unlikely that these regions would participate in such an agreement (Edmonds *et al*., 1995).

Alternatively, with a common global carbon tax and full participation, the burden of abatement costs would be distributed unevenly across the world and would change with time. A large burden would fall on OECD and economies in transition in the early years, shifting to developing nations in later years (Edmonds *et al*., 1995). Transition economies would thus be unlikely to participate in a common global carbon tax agreement. If such nations were to participate in the short run, growth and changing economic and political circumstances may increase the probability of their dropping out of a tax agreement when they face increasing net participation costs (Edmonds *et al.*, 1995).

The equity implications of a global tradable quota system depend on quota allocation. The portion of global abatement costs borne by a country or group of countries depends on its relative position in the quota market; net sellers of quota effectively receive income transfers from net buyers. *Table 6.3* describes the relative position of groups of countries in an international quota market, based on six possible initial allocations (Edmonds *et al*., 1995).[102]

Of course, a country's participation in an allocation scheme depends on net costs (the sum of transfer payments associated with quota trade, plus direct mitigation costs), not just the direction of income transfers. However, that the direction of transfers may change over time, especially for China and the transition economies, complicates the incorporation of equity goals in quota system design (Edmonds *et al*., 1995). Although quota allocation is referred to here, the analysis applies equivalently to redistributing international carbon tax revenues (Pezzey, 1992; Rose *et al*., 1998).

Bohm and Larsen (1994) explore the participation implications of two of the more frequently discussed of the allocation schemes listed in *Table 6.3* (allocation by population and by GDP) for a quota regime covering Western Europe and Eastern Europe. Both of these allocations, and combinations thereof, lead to substantial losses by the Eastern European countries, making their participation unlikely (Bohm and Larsen, 1994). Given the aggregate cost-savings associated with their participation, an ideal allocation system would provide the minimum possible participation incentive to the Eastern European countries, while maximizing potential abatement cost savings to the western countries. The authors identify this lower bound in terms of eastern country quota-to-emissions ratios that would induce participation, ranging among countries from 0.85 to 0.91. This incentive scenario results in zero net gains (losses) to the eastern countries, and net costs to each western country of 0.09% of GDP. In the presence of wide disparity in current regional economic welfare, the perceived equity benefits of such a scenario may facilitate a more cost-effective agreement than any that might be achieved without Eastern European participation.[103]

If quota allocations are used to induce participation by transition economies and developing countries, the international wealth transfers that occur as a result may cause fluctuations in real exchange rates and international capital and trade flows (McKibbin and Wilcoxen, 1997a, 1997b). The magnitude of these fluctuations and the extent to which they could be problematic are uncertain. McKibbin and Wilcoxen (2000) suggest an alternative approach to the problem of equity versus participation incentive, which includes both short-run emissions quota and long-run emissions "endowments". In this approach, the price of emissions quota is set through international negotiation at regular intervals (they suggest every decade), and each country issues as many quotas as necessary to keep the price at the negotiated level. The price of emissions endowments, however, is flexible, and the quantity allowed per country is fixed. Each participating country's endowment prices reflect expected future prices of emissions quota.

[101] Hoel (1997) uses a simple model of a group of identical countries that interact through mobile real capital. Given the total stock of real capital for the group of countries as a whole, he demonstrates that if competition in the goods markets is imperfect or if unemployment exists, a lack of international policy co-ordination may lead to outcomes that are not Pareto optimal. However, he finds there is no need for policy co-ordination if after-tax wages are exogenous, but this seems to be a rather strong assumption.

[102] Rose *et al*. (1998) analyzed the welfare impacts of various tradable permit allocations and obtained results that are consistent with many of the results of Edmonds *et al*. (1995).

[103] GDP per capita in 1989 ranged from US$1,200–1,500 in Albania, Turkey, Tajikistan, and Uzbekistan to more than US$20,000 in Switzerland, Luxembourg, and the Scandinavian countries (Bohm and Larsen, 1994).

Table 6.3: *Direction of income transfers in international emissions trading, six possible quota allocation schemes*

	Anticipated position of participating countries, 2005-2095			
Tradable quota allocation	**OECD countries**	**EITs**	**China and other centrally-planned Asian countries**	**Rest of world**
Grandfathering	Net sellers	Net sellers	Net buyers	Net buyers
Equal per-capita emissions	Net buyers	Net buyers	Net sellers early, Net buyers post-2035	
GDP-weighted emissions	Net sellers	Net effect small and ambiguous	Net buyers	Net effect small and ambiguous
GDP-adjusted grandfathering	Net buyers	Net sellers	Net effect small and ambiguous	Net effect small and ambiguous
No harm to developing nations	Net buyers	Net sellers early, net buyers post-2035	Net sellers	Net sellers
No harm to non-OECD nations	Net buyers	Net sellers early, net buyers post-2035	Net sellers	Net sellers

Source: Edmonds *et al*. (1995).
Notes: Under GDP-adjusted grandfathering, emissions rights have a baseline at current levels, adjusted for income growth. The "no harm" scenarios allocate sufficient quota to the relevant countries to cover their own emissions and to generate enough revenue to cover economic costs of protocol participation.

6.5 Key Considerations

This section deals with the most important aspects that could be considered in designing climate change policy.

6.5.1 Price versus Quantity Instruments

Optimal climate change policy–irrespective of whether it is national or international–under uncertainty and/or asymmetric information deviates from more typical analyses with best-guess parameter values and/or information symmetry, not only in terms of the stringency of policies, but also in terms of policy design (Weitzman, 1974). Depending on the degree of uncertainty and correlation between the marginal damage and MAC curves, taxes could be a better or inferior alternative to tradable permits (Watson and Ridker, 1984; Stavins, 1996).[104] Recent literature shows that taxes dominate quotas for the control of GHGs when the environmental damage function is rather flat (Hoel and Karp, 1998). Hoel (1998) and Pizer (1997b) point out that the lack of a clear, short-term threshold for severe climate damages favours the use of market-based policies, like taxes, that limit cost uncertainty. In addition, there is mounting evidence that rigid emission limits are not appropriate in the short run under a weak emissions reduction regime (Newell and Pizer, 1998).

Recently, Pizer (1997a) argued that excluding uncertainty might lead to policy recommendations that are too lax. Ebert (1996) has argued that improving the information of the regulator is crucial, because decision makers always overestimate abatement costs if they neglect that firms possess an abatement option other than decreasing output–additional abatement technology.

To increase the effectiveness and efficiency of domestic GHG emissions reduction policies, it is argued that governments could adopt policies that take a comprehensive approach, stimulating the development of all kinds of new materials, materials substitution, product re-design, resource productivity, and waste management strategies that can reduce GHG emissions. Moreover, governments could set long-term GHG emissions reduction targets, since the optimal set of technical options at low GHG mitigation levels may not include options that are efficient at high GHG emissions reduction levels.

[104] Montero (2000b) finds that under incomplete enforcement tradable permits perform relatively better than taxes.

6.5.2 Interactions of Policy Instruments with Fiscal Systems

It is important to consider how the domestic policy instruments examined in this chapter may interact with existing fiscal systems, because such interactions can have significant effects on the overall costs of achieving specified GHG emissions reduction targets. A growing literature demonstrates theoretically, and with numerical simulation models, that the costs of addressing GHG targets with policy instruments of all kinds–command-and-control as well as market-based approaches–can be greater than anticipated because of the interaction of these policy instruments with existing domestic tax systems.[105] Domestic taxes on labour and investment income change the economic returns to labour and capital, and distort the efficient use of these resources.

The cost-increasing interaction reflects the impact that GHG policies can have on the functioning of labour and capital markets through their effects on real wages and the real return to capital (see, e.g., Parry *et al*., 1999). By restricting the allowable GHG emissions, permits, regulations, or a carbon tax raise the costs of production and the price of output, thus reducing the real return to labour and capital, and exacerbating prior distortions in the labour and capital markets. Thus, to attain a given GHG emissions target, before or after use of IET and other Kyoto mechanisms, all the instruments have a cost-increasing "interaction effect".

For policies that raise revenue for the government, carbon taxes and auctioned permits, this is only part of the story, however. These revenues can be recycled to reduce existing distortionary taxes. Thus, to attain a given GHG emissions target, revenue-generating policy instruments have the advantage of a potential cost-reducing "revenue-recycling effect" as compared to the alternative, non-auctioned tradable permits or other non-revenue-generating instruments (Bohm, 1998). For a more complete theoretical discussion, see Chapter 7, and see Chapter 8 for the empirical results.

6.5.3 The Effects of Alternative Policy Instruments on Technological Change

In the long run, the development and widespread adoption of new technologies can greatly ameliorate what, in the short run, sometimes appear to be overwhelming conflicts between economic well being and environmental quality. Therefore, the effect of public policies on the development and spread of new technologies may be among the most important determinants of success or failure in environmental protection (Kneese and Schultze, 1975).

[105] For the basic analysis and economic intuition of this literature, see Kolstad (2000, pp. 281–284).

To achieve widespread benefits from a new technology, three steps are required (Schumpeter, 1942):
- invention, the development of a new technical idea;
- innovation, the incorporation of a new idea into a commercial product or process and the first marketplace implementation thereof; and
- diffusion, the typically gradual process by which improved products or processes become widely used.

Rates of invention, innovation, and technology diffusion are affected by opportunities that exist for firms and individuals to profit from investing in research, in commercial development, and in marketing and product development (Stoneman, 1983).

Governments often seek to influence each of these directly, by investment in public research, subsidies to research and technological development, dissemination of information, and other means (Mowery and Rosenberg, 1989). Policies with large economic impacts, such as those intended to address global climate change, can be designed to foster technological invention, innovation, and diffusion (Kemp and Soete, 1990). For the impact of R&D policies on technology development and transfer, see the IPCC Special Report on Technology Transfer (IPCC, 2000).

To examine the link between policy instruments and technological change, environmental policies can be characterized as market-based approaches, performance standards, technology standards, and voluntary agreements. All these forms of intervention have the potential to induce or force some amount of technological change, because by their very nature they induce or require firms to do things they would not otherwise do. Performance and technology standards can be explicitly designed to be "technology forcing", mandating performance levels that are not currently viewed as technologically feasible or mandating technologies that are not fully developed. The problem with this approach can be that while regulators typically assume that some amount of improvement over existing technology will always be feasible, it is impossible to know how much. Standards must either be made not very ambitious, or else run the risk of being ultimately unachievable, which leads to great political and economic disruption (Freeman and Haveman, 1972). However, in the case of obstructed technology, regulators know quite well the technology improvements that are feasible. Thus, although the problem of standards being either too low or too ambitious remains a possibility, it does not make standards inherently incapable of implementing some portion of the available technology base, and to do so cost-effectively on the basis of cost–benefit tests.[106]

[106] There is, however, an interesting example in which ambitious standards were finally achieved. New emission standards for passenger cars (the so-called "Muskie" standard), when first enacted in the USA in 1970, were thought to be too ambitious because no such technologies existed in the world. However, a technology breakthrough by two automobile manufacturers in Japan achieved the standard (Honma, 1978; OECD, 1978).

6.5.3.1 Theoretical Analyses

Most of the work in the environmental economics literature on the dynamic effects of policy instruments on technological change has been theoretical, rather than empirical, and the theoretical literature is considered first. The predominant theoretical framework involves what could be called the "discrete technology choice" model. In this, firms contemplate the use of a certain technology that reduces the marginal costs of pollution abatement and that has a known fixed cost (Downing and White, 1986; Jung *et al*., 1996; Malueg, 1989; Milliman and Prince, 1989; Zerbe, 1970).

While some authors present this approach as a model of innovation, it is perhaps more useful as a model of adoption.[107] The adoption decision is one in which firms face a given technology with a known fixed cost and certain consequences, and must decide whether or not to use it; this corresponds precisely to the discrete technology choice model. Innovation, on the other hand, involves choices about research and development expenditures, with some uncertainty over the technology that will result and the costs of developing it. Models of innovation allow firms to choose their research and development expenditures, as in Magat (1978, 1979), or incorporate uncertainty over the outcome of research (Biglaiser and Horowitz, 1995; Biglaiser *et al*., 1995).

Several researchers have found that the incentive to adopt new technologies is greater under market-based instruments than under direct regulation (Downing and White, 1986; Jung *et al*., 1996; Milliman and Prince, 1989; Zerbe, 1970). This view is tempered by Malueg (1989), who points out that the adoption incentive under a freely allocated tradable permits system depends on whether a firm is a buyer or seller of permits. For permit buyers, the incentive is larger under a performance standard than under tradable permits.

Comparisons among market-based instruments are less consistent. Downing and White (1986), who consider the case of a single (sole) polluter, argue that taxes and tradable permit systems are essentially equivalent. On the other hand, Milliman and Prince (1989) find that auctioned permits provide the largest adoption incentive of any instrument, with emissions taxes and subsidies second, and freely allocated permits and direct controls last. Jung *et al*. (1996) consider heterogeneous firms, and model the "market-level incentive" created by various instruments. This measure is simply the aggregate cost savings to the industry as a whole from adopting the technology. Their rankings echo those of Milliman and Prince (1989).

[107] Zerbe (1970) couches his research in terms of adoption. Downing and White (1986) frame their work in terms of innovation. Milliman and Prince (1989) use one model to discuss both diffusion and innovation, the latter being defined essentially as the initial use of the technology by an "innovating" firm. Malueg (1989) presents the same framework as a model of adoption. Jung *et al*. (1996) present their model as one of either adoption or innovation.

On the basis of an analytical and numerical comparison of the welfare impacts of alternative policy instruments in the presence of endogenous technological change, Fischer *et al*. (1998) argue that the relative ranking of policy instruments depends critically on firms' ability to imitate innovations, innovation costs, environmental benefit functions, and the number of firms that produce emissions.[108] Finally, the study includes an explicit model of the final output market, and finds that it depends upon empirical values of the relevant parameters whether (auctioned) permits or taxes provide a stronger incentive to adopt an improved technology.

Finally, recent research investigates the combined effect of the pollution externality and the positive externality that results from learning-by-doing with mitigation technologies. Since the benefit from learning occurs after the learning has taken place, a dynamic analysis is needed. Some analyses shown that dynamic efficiency (discounted least cost, aggregated over time) requires that the incentive for emissions-mitigating innovations be set higher than the penalty on emissions, especially if account is taken of "leakage". This is in contrast with the conclusions of comparative static analysis upon which most environmental policy analysis is grounded (e.g., Baumol and Oates, 1988), under which the two incentives should be equal in all time periods (for a formal analysis, see Read (1999, 2000)).

6.5.3.2 Empirical Analyses

Empirical analyses[109] of the relative effects of alternative environmental policy instruments on the rate and direction of technological change are limited in number, but those available focus on technological change in energy efficiency, and thus are potentially of direct relevance to global climate policy. These studies can be considered within the three stages of technological change introduced above–invention, innovation, and diffusion. It is most illuminating, however, to consider the three stages in reverse order.

Beginning, then, with empirical analyses of the effects of environmental policy instruments on technology diffusion, Jaffe and Stavins (1995) conducted econometric analyses of the factors that affected the adoption of thermal insulation technologies in new residential construction in the USA from 1979 to 1988. They examined the dynamic effects of energy prices and technology adoption costs on average residential energy-efficient technologies in new home construction. The effects of

[108] Related to this is the finding of Parry (1998) that the welfare gain induced by an emissions tax is significantly greater than that induced by other policies only for very major innovations. Also related is Montero's (2000c) conclusion that the relative superiority of alternative policy instruments in terms of their effects on firm investments in R&D depends upon the nature of the underlying market structure. This is implied by Laffont and Tirole (1996).

[109] For further literature references, see Chapter 8.

energy prices can be interpreted as suggesting what the likely effects of taxes on energy use would be, and the effects of changes in adoption costs can be interpreted as indicating what the effects of technology-adoption subsidies would be. They found that the response of mean energy efficiency to energy price changes was positive and significant, both statistically and economically. Interestingly, they also found that equivalent percentage cost subsidies would have been about three times as effective as taxes in encouraging adoption, although standard financial analysis suggest they ought to be about equal in percentage terms. This finding does, however, offer confirmation for the conventional wisdom that technology adoption decisions are more sensitive to up-front cost considerations than to longer-term operating expenses.

In a study of residential conservation investment tax credits, Hassett and Metcalf (1995) also found that tax credit or deductions were many times more effective than "equivalent" changes in energy prices–about eight times as effective in their study. They speculate that one reason for this difference is that energy price movements may be perceived as temporary. The findings by Jaffe and Stavins (1995), and by Hasset and Metcalf (1995) are consistent with other analyses of the relative effectiveness of energy prices and technology market reforms in bringing about the adoption of lifecycle cost-saving technologies. Up-front subsidies can be more effective than energy price signals (see, e.g., Krause *et al.,* 1993; Howarth and Winslow, 1994; IPSEP, 1995; Eto *et al.*, 1996; Golove and Eto, 1995; IPCC, 1996, Executive Summary, p. 13). A disadvantage of such non-price policies relative to administered prices is that they have to be implemented on an "end-use by end-use" or "sector by sector" basis in a customized fashion. Also, an effective institutional and regulatory framework needs to be created and maintained to evaluate and ensure the continued cost-effectiveness of such policies.

This and other research on energy efficiency programmes also highlights a major difference in the way energy price signals and technology subsidies function. The technology adoption response to taxes may include a secondary increase in the demand for energy services. This secondary effect takes two forms: a direct effect that results from the increased utilization of energy-using equipment and capital stocks, and an indirect effect from increased disposable income. Studies of such demand effects suggest that the combined effects are generally not sufficient to offset more than a minor portion of emissions reductions.

In addition, technology subsidies and tax credits can require large public expenditures per unit of effect, since consumers who would have purchased the product even in the absence of the subsidy will still receive it.[110]

Some recent empirical studies suggest that the response of relevant technological change to energy price changes can be surprisingly swift. Typically, this is less than 5 years for much of the response in terms of patenting activity and the introduction of new model offerings (Jaffe and Stavins, 1995; Newell *et al.*, 1999; Poppe, 1999). Substantial diffusion can sometimes take longer, depending on the rate of retirement of previously installed equipment. The longevity of much energy-using equipment reinforces the importance of taking a longer-term view towards energy-efficiency improvements–on the order of decades.

An optimal set of policies would be designed in such a way as to achieve two outcomes simultaneously: release any obstructed emission and cost-reduction potentials from already available technologies through various market reforms that try to reduce market distortions (see IPCC, 2000), and induce the accelerated development of new technologies. This approach allows significant carbon abatement over the near-term by diffusing existing technologies, while at the same time preparing new technologies for the longer term.

6.6 Climate Policy Evaluation

Theoretically, it is unnecessary to monitor and evaluate national policies and programmes to see whether Annex I Parties fulfil their Kyoto commitments, provided national communications give a clear and reliable picture of the net impact of those actions on the net national GHG emissions and net uptake via sinks. Indeed, national inventories, usually updated on an annual basis, are the backbone of the monitoring system. Of course, governments might want to monitor the impact of their own policies for domestic assessment purposes. To meet the international commitments, such monitoring, however, would not be necessary if monitoring at the aggregate level were completely reliable. However, this may not be true. Evidence suggests that there can be a considerable margin of error in the national data provided to the UNFCCC Secretariat within the framework of the national communications.

Over the past 25 years an extensive literature, including programme evaluation, value-for-money audits, and comprehensive audits, has developed on the evaluation of government programmes. Much of this literature is specific to the type of programme–low-income housing, training, employment creation, policing, transit, energy efficiency, etc.–and has little relevance to the monitoring and evaluation of policies for climate change mitigation. However, the literature also includes numerous evaluations of energy-efficiency, DSM, emissions trading, environmental taxes, and other programmes that could provide useful insights into the design, monitoring, and evaluation of climate change policies.

[110] It may be possible to reduce the number of free-riders through subsidy programme design.

References

ADEME-European Commission, 1999: *Energy Efficiency Indicators: The European Experience*.ADEME, Paris.

Ahn, D., 1999: Environmental Disputes in the GATT/WTO: Before and After the US-Shrimp Case. *Michigan Journal of International Law,* **20**, 819-870.

Austin, D., P. Faeth, R. Serôa da Motta, C.E.F. Young, C. Ferraz, Z. Ji, L. Junfeng, M. Pathak, and L. Srivastava, 1998: *Opportunities for financing sustainable development via the CDM: A Discussion Draft.* Tata Energy Research Institute, Instituto de Pesquisa Economica Aplicada, Institute of Environmental Economics at the Renmin University of China, and World Resources Institute, Washington, DC.

Australia, Canada, Iceland, Japan, New Zealand, Norway, Russian Federation, and the United States of America, June 1998: *Non-Paper on Principles, Modalities, Rules, and Guidelines for an International Emissions Trading Regime*. http://wwwmed.govt.nz/ers/environment/umbrellagroup/index.html

Barrett, S., 1994: Strategic environmental policy and international trade. *Journal of Public Economics,* **54**, 325-338.

Baron, R. 1996: Economic/fiscal instruments: Taxation (i.e. carbon/energy), policies and measures for common action, Working Paper. Annex I Experts Group on the UNFCCC, OECD WPAPER No.4.

Baron, R., 1999: An assessment of liability rules for international GHG emissions trading, IEA Information Paper. International Energy Agency, Paris.

Baron, R., and J. Hou, 1998: Electricity trade, the Kyoto Protocol and emissions trading, IEA Information Paper for the Fourth Conference of the Parties to the UNFCCC. IEA, Paris.

Baron, R., and A. Lanza, 2000: Kyoto commitments: macro and micro insights on trading and the clean development mechanism. *Integrated Assessment, 1 (2),* 137-144.

Baron, R., M. Bosi, A. Lanza, and J. Pershing, 1999: *A Preliminary Analysis of the EU Proposal on the Kyoto Mechanisms*. International Energy Agency, Paris.

Barros, V., and M. Conte Grand, 1999: *El significado de una meta dinámica de reducción de emisiones de gases efecto invernadero: el caso Argentino (documento de trabajo).* Universidad del CEMA, Buenos Aires, Argentina.

Bashmakov, I., 1998: *Strengthening the Russian economy through climate change policies.* Proceedings, Dealing with Carbon Credits After Kyoto, May 28-29, Callantsoog, Netherlands.

Bashmakov, I., 2000: Energy Subsidies and "Right Prices". *Energy Efficiency*, **27**, April-June 2000.

Bashmakov, I., and S. Sorokina, 1996: *Refrigerator energy efficiency standards in Eastern Europe*. Center for Energy Efficiency (CENEf), Moscow.

Baumol, W.J., and W.E. Oates, 1988: *The Theory of Environmental Policy, Second Edition*. Cambridge University Press, New York.

Begg, K., S.D. Parkinson, T. Jackson, P-E. Morthorst, and P. Bailey, 1999: *Overall Issues for Accounting for the Emissions Reductions of JI Projects.* Proceedings of Workshop on Baselines for the CDM, Tokyo, February 25-26, 1999, Global Industrial and Social Progress Research Institute (GISPRI).

Begg, K.G., S.D. Parkinson, Y. Mulugetta, and R. Wilkinson, 2000: An initial evaluation of CDM type projects in DC's. Final Report to DFID.

Benner, J., 2000: *Development of an International Green Certificate Trading System*. Proceedings of the Fifth National Green Power Marketing Conference, August 8, Denver, CO.

Berger, J.R., 1999: Unilateral Trade Measures to Conserve the World's Living Resources: An Environmental Breakthrough for the GATT in the WTO Sea Turtle Case. *Columbia Journal of Environmental Law*, **24**, 355-411.

Bernstein, J., 1993: Alternative approaches to pollution control and waste management regulatory and economic instruments. Urban Management Program UNDP/UNCHS, World Bank, Washington DC.

Bernstein, P.M., W. Montgomery, T. Rutherford, and G. Yang, 1999: Effects of restrictions on international permit trading: The MS-MRT model. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 221-256.

Biglaiser, G., and J.K. Horowitz, 1995: Pollution regulation and incentives for pollution-control research. *Journal of Economic Management Strategy,* **3,** 663-684.

Biglaiser, G., J.K. Horowitz, and J.Quiggin, 1995: Dynamic pollution regulation. *Journal of Regulatory Economics,* **8**, 33-44.

Black, D., M. Grubb, and C Windham, 2000: *International Trade and Climate Change Policies*. The Royal Institute of International Affairs, London.

Bluffstone, R., and B.A. Larson, 1997: *Controlling Pollution in Transition Economies*. Edward Elgar, Cheltenham, UK.

Bohm, P., 1994: On the feasibility of Joint Implementation of carbon emissions reductions, *Climate Change: Policy Instruments and their Implications.* Proceedings of the Tsukuba Workshop of IPCC Working Group III, A. Amano (ed.), Center for Global Environmental Research, Environment Agency of Japan, Tsukuba, Japan.

Bohm, P., 1997: Joint Implementation as Emission Quota Trade: An Experiment Among Four Nordic Countries. *Nord,* **4**, Nordic Council of Ministers, Copenhagen. Reprinted (with the exception of Appendix 3) in *Pollution for Sale*. S. Sorrell, J. Skea (eds.), Edward Elgar, Cheltenham, UK, 1999.

Bohm, P., 1998: Public investment issues and efficient climate change policy, part 1. In *The Welfare State, Public Investment, and Growth*. H. Shibata and T. Ihori, (eds.), Springer Verlag, Tokyo.

Bohm, P., 1999: *International GHG emission trading with special reference to the Kyoto Protocol, TemaNord:506.* Nordic Council of Ministers, Copenhagen.

Bohm, P., and B. Larsen, 1994: Fairness in a tradable-permit treaty for carbon emissions reductions in Europe and the former Soviet Union. *Environmental and Resource Economics,* **4**, 219-239.

Bohm, P., and B. Carlén, 2000: Cost-effective approaches to attracting low-income countries to international emissions trading: Theory and experiment. In *Studies in Climate Change Policy: Theory and Experiments*, PhD thesis B. Carlén, Department of Economics, Stockholm University, Stockholm.

Böhringer, C., and T.F. Rutherford, 1997: Carbon taxes with exemptions in an open economy: A general equilibrium analysis of the German Tax Initiative. *Journal of Environmental Economics and Management,* **32**(2), 189-203.

Bollen, J., A. Gielen, and H. Timmer, 1999: Clubs, ceilings and CDM: Macroeconomics of compliance with the Kyoto Protocol, *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 177-206.

Boom, J.T., 1998: *Market performance and environmental policy: Four tradable permits scenarios, SOE*. Foundation for Economic Research of the University of Amsterdam.

Bovenberg, L., and L. Goulder, 1999: Neutralizing the adverse industry impacts of CO_2 abatement policies: What does it cost? Paper prepared for the FEEM-NBER Conference on Behavioural and Distributional Effects of Environmental Policy, June, Milan, Italy.

Boyle, S., 1996: DSM Progress and lessons in the Global Context. *Energy Policy,* **24**(4), 345-360.

Brown, M.A., M.D. Levine, J.P. Romm, A.H. Rosenfeld, and J.G. Koomey, 1998: Engineering-Economic Studies of Energy Technologies to Reduce Greenhouse Gas Emissions: Opportunities and Challenges. *Annual Review Energy Environ*ment, **23**, 287-385.

Buchanan, J.M., and G. Tullock, 1975: Polluters, profits and political response: Direct controls vs. taxes. *American Economic Review,* **65**(1), 139-147.

California Assembly Bill No. 1890, 1996: Chapter 854 signed September 23 1996.

Carlén, 1999: Large-country effects in international emissions trading: A laboratory test. Working Paper #15, Department of Economics, Stockholm University, Stockholm.

Carraro, C., and D. Siniscalco, (eds.), 1993: The European carbon tax: An economic assessment, Fondazione ENI, Enrico Mattei Series on Economics. *Energy and Environment*.

CCAP (Center for Clean Air Policy), 1998: US carbon emissions trading: Description of an upstream approach. [online: http://www.ccap.org].

CEC, 1996: Communication from the Commission to the Council and the European Parliament on Environmental Agreements, COM(96) 561 Final, 1996.

Chadwick, M., K. Begg, G. Haq, and T. Jackson, 2000: Environmental and Social aspects of JI -methodologies and case study results, Chapter 6. *Flexibility in Climate Policy: Making the Kyoto Mechanisms Work.* T. Jackson, K. Begg, S.D. Parkinson, (eds.), Earthscan, UK.

Chandler, W., 2000: *Energy and the environment in the transition economies: between cold war and global warming.* Westview Press, USA.

Chomitz, K., 1998: *Baselines for GHG reductions: Problems, precedents, solutions*. World Bank, Washington, DC.

Cole, D., and P.Z. Grossman, 1998: When is command-and-control efficient? Institutions, technology and the comparative efficiency of alternative regulatory regimes for environmental protection. Working Paper Series, Indiana University and Butler University, USA.

Conrad, K., 1996: Choosing emission taxes under international price competition. In *Environmental Policy and Market Structure.* C. Carraro, Y. Katsoulacos, and A. Xepapadeas, (eds.), 85-98.

Cooper, A., S. Livermore, V. Rossi, A. Wilson, and J. Walker, 1999: The economic implications of reducing carbon emissions: A cross-country quantitative investigation using the Oxford Global Macroeconomic and Energy Model. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 335-366.

Cooper, R., 1998: Toward a real global warming treaty. *Foreign Affairs,* **77**(2), 66-79.

Corfee Morlot, J., 1998: Ensuring Compliance with a Global Climate Change Agreement. OECD Information Paper, Paris.

Cramton, P., and S. Kerr, 1998: *Tradable carbon permit auctions – how and why to auction not grandfather*. University of Maryland/Resources for the Future, Washington, DC.

Crawford-Smith, C., 1999: *The Market for Green Power in Australia - Future Role and Implications*. World Renewable Energy Congress, Murdoch University, Perth, WA.

Criqui, P., S. Mima, and L. Viguier, 1999: Marginal Abatement Costs of CO_2 Emissions Reductions, Geographic Flexibility and Concrete Ceilings. An Assessment Using the POLES Model. *Energy Policy*, **27**, 585-601.

Demaret, P., and R. Stewardson, 1994: Border Tax Adjustments under the GATT and EC Law and General Implications for Environmental Taxes. *Journal of World Trade*, **28**(4), 5-65.

Dijkstra, B.R., 1998: *The Political Economy of Instrument Choice in Environmental Policy*. Groningen University, Groningen, The Netherlands.

Dixon, R.K., 1999: *The United Nations Framework Convention on Climate Change Activities Implemented Jointly Pilot: Experiences and Lessons Learned*. Kluwer, Dordrecht.

Downing, P.B., and L.J. White, 1986: Innovation in pollution control. *Journal of Environmental Economics and Management,* **13,** 18-29.

Dutschke, M., and A. Michaelowa, 1998: Issues and open questions of greenhouse gas emission trading under the Kyoto Protocol. Discussion paper 68, HWWA, Hamburg Institute for International Economics, Hamburg.

Eaton, J., and G.M. Grossman, 1986: Optimal trade and industrial policy under oligopoly. *Quarterly Journal of Economics,* **100**, 383-406.

Ebert, U., 1996: Naïve use of environmental instruments. In *Environmental Policy and Market Structure*, C. Carraro, Y. Katsoulacos, and A. Xepapadeas, (eds.), pp. 45-64.

ECMT, 1998: *Efficient Transport for Europe*. OECD Publications, Paris.

Edmonds, J., M. Wise, and D.W. Barns, 1995: Carbon coalitions: The cost and effectiveness of energy agreements to alter trajectories of atmospheric carbon dioxide emissions. *Energy Policy,* **23**(4/5), 309-335.

EEA, 1997: *Environmental Agreements - Environmental Effectiveness*. European Environment Agency, Copenhagen.

EIA, 1998: Emissions of GHGs in the United States 1997. Energy Information Administration, U.S. Department of Energy, DOE/EIA-0573(97), Washington, DC.

EIA, 1999: *Annual Energy Outlook 2000*. Energy Information Administration, U.S. Department of Energy, December 1999, Washington, DC.

Eichhammer, W., and Jochem, E., 1998: Voluntary Agreements for the reduction of CO_2 GHG emissions in Germany and their recent first evaluation. Paper prepared for CAVA Workshop, Gent, Belgium.

Elbers, C., and C. Withagen, 1999: General equilibrium models of environmental regulation and international trade. Center for Economic Research, paper no. 9924, Tilburg University, Tilburg, The Netherlands.

Ellerman, A.D.,and A. Decaux, 1998: *Analysis of post-Kyoto CO_2 emissions trading using marginal abatement curves*. Report 40, Joint Program on the Science and Policy of Global Change, Massachusetts Institute of Technology, Cambridge, MA.

Ellerman, A.D., and I.S. Wing, 2000: *Supplementarity: An Invitation to Monopsony? MIT Joint Program on the Science and Policy of Climate Change*. Report No. 59 (April, 2000).

Ellis, J., 1999: Experience with emission baselines under the AIJ pilot phase. OECD Information Paper, Paris.

Esty, D.C., 1994: *Greening the GATT: trade, environment and the future*. Institute for International Economics, Washington, DC.

Eto, J., R. Prahl, and J. Schlegel, 1996: *A Scoping Study on Energy Efficiency Market Transformation by California Utility DSM Programs*, LBNL-39058. Energy and Environment Division, Lawrence Berkeley Laboratory, Berkeley CA.

Eyre, N.J., 1998: A Golden Age or a False Dawn? Energy Efficiency in UK Competitive Energy Markets. *Energy Policy,* **26** (12), 963-972.

Fenden, P., 1998: Norwegian Industry's Network for Energy Conservation.Industrial Energy Efficiency Policies: Understanding Success and Failure. Workshop organized by International Network for Energy Demand Analysis in the Industrial Sector, June 1998, Utrecht, The Netherlands.

Fischer, C., I.W.H. Parry, and W. Pizer, 1998: Instrument choice for environmental protection when technological innovation is endogenous. Resources for the Future Discussion Paper 99-04 (revised), Washington, DC.

Fisher-Vanden, K., 1999: Structural change and technological diffusion in transition economies: Implications for energy use and carbon emissions in China. Unpublished PhD thesis, Harvard University, Cambridge, MA.

Fowlie, M., 1999: *The Environment and Competition in Electricity in the USA and the UK*. Oxford Institute for Energy Studies, Oxford, UK.

Freeman, A.M., III, and R.H. Haveman, 1972: Clean rhetoric and dirty water. *Public Interest,* **28**, 51-65.

Garbaccio, R., M. Ho, and D.W. Jorgenson, 1999: Why has the energy-output ratio fallen in China? *Energy Journal*.

Glasbergen, P., M.C. Das, P.P.J. Driessen, N. Habermehl, W.J.V. Vermeulen, K. Blok, J. Farla, and E. Korevaar., 1997: *Afspraken werken. Evaluatie Meerjarenafspraken over Energie-efficiency*. Ministry of Economic Affairs, Directorate-General for Energy, The Hague, 197 pp.

Goldberg, D., S. Porter, N. LaCasta, and E. Hillman, 1998: *Responsibility for non-compliance under the Kyoto Protocol's mechanisms for cooperative implementation.* Center for International Environmental Law and Euronatura, Washington, DC.

Goldemberg, J., 1998: *Issues & options: The Clean Development Mechanism*. United Nations Development Program, New York, NY.

Golove, W., and J. Eto 1995: *Market Barriers to Energy Efficiency: A Critical Reappraisal of Public Policies to Promote Energy Efficiency, LBNL-38059*. Energy and Environment Division, Lawrence Berkeley Laboratory. Berkeley, CA.

Goodin, R.E., 1994: Selling Environmental Indulgences. *Kyklos,* **47**(4), 573-596.

Grubb, M., T. Chapuis, and M.H. Duong, 1995: The economics of changing course: Implications of adaptability and inertia for optimal climate policy. *Energy Policy,* **23**(4/5), 417-432.

Grubb, M., T. Tietenberg, B. Swift, A. Michaelowa, Z. Zhang, and F.T. Joshua, 1998: *GHG Emissions Trading: Defining the Principles, Modalities, Rules and Guidelines for Verification, Reporting & Accountability*. United Nations Conference on Trade and Development, Geneva.

Haddad, B.M., and P. Jefferis, 1999: Forging consensus on National Renewables Policy: The Renewables Portfolio Standard and the National Public Benefit Trust Fund. *Electricity Journal*, **12**(2), 68-80.

Hadley, S., and E. Hirst, 1995: *Utility DSM Programs from 1989 through 1998: Continuation or Cross Roads? ORNL/CON-405.* Oak Ridge National Laboratory, Oak Ridge, TN.

Hahn, R.W., 1987: Jobs and environmental quality: Some implications for instrument choice. *Policy Sciences*, **20**, 289-306.

Hahn, R.W., 1989: Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders. *Journal of Economic Perspectives,* **3**(2), 95-114.

Hahn, R.W., and R.N. Stavins, 1991: Incentive-based environmental regulation: A new era from an old idea? *Ecology Law Quarterly,* **18**(1), 1-42.

Hahn, R.W., and R.N. Stavins, 1999: What has Kyoto wrought? The real architecture of international tradable permit markets, working paper. Cambridge, MA.

Haites, E., 1998: International emissions trading and compliance with GHG limitation commitments. Working Paper W70, International Academy of the Environment.

Haites, E., and A. Proestos, 2000: Suitability of non-energy GHGs for emissions trading. In *Non-CO_2 Greenhouse Gases: Scientific Understanding, Control and Implementation*. J. van Ham, A.P.M. Baede, L.A. Meyer, R. Ybema, (eds.), Kluwer Academic Publishers, Dordrecht, 417-424.

Haites, E., and F. Yamin, 2000: The Clean Development Mechanism: Proposals for its operation and governance. *Global Environmental Change*, **10**(1), 27-45.

Han, K., and J.B. Braden, 1996: Environment and trade: New evidence from US manufacturing. Unpublished research paper, Department of Economics, University of Illinois, and Department of Agriculture and Consumer Economic, University of Illinois at Urbana-Champaign, IL.

Hargrave, T., N. Helme, and I. Puhl, 1998: *Options for simplifying baseline setting for Joint Implementation and Clean Development Mechanism projects*. Center for Clean Air Policy (CCAP), Washington, DC.

Harrison, D., and T. Schatzki, 2000: *Certifying baselines for credit-based greenhouse gas trading programs: Lessons from experience with environmental and non-environmental programs*. EPRI, Palo Alto, CA.

Hassett, K.A., and G.E. Metcalf, 1995: Energy tax credits and residential conservation investment: Evidence from panel data. *Journal of Public Economics,* **57**, 201-217.

Hassing, P., and M. S. Mendis, 1999: An international market framework for CDM transactions. Paper presented at the UNFCCC technical workshop, Bonn, Germany.

Hauch, J., 1999: *Elephant – A Simulation Model for Environmental Regulation at Nordic Energy Markets.* Ph.D. thesis, Danish Economic Council, Copenhagen.

Hoel, M., 1993: Harmonization of carbon taxes in international climate agreements. *Environmental and Resource Economics,* **3**(3), 221-232.

Hoel, M., 1996: Should a carbon tax be differentiated across sectors? *Journal of Public Economics,* **59**(1), 17-32.

Hoel, M., 1997: Coordination of environmental policy for transboundary environmental problems. *Journal of Public Economics,* **66**, 199-224.

Hoel, M., 1998: Emission taxes versus other environmental policies. *Scandinavian Journal of Economics,* 100(1), 79-104.

Hoel, M., and L. Karp, 1998: Taxes versus quotas for a stock pollutant. Working Paper No. 885. Department of Agricultural and Resource Economics and Policy (CUDARE). University of Berkeley, California.

Holt, E., 2000a: *Green Power in Competitive Markets, 1999*. Electric Power Research Institute, TR-114210, Palo Alto, CA.

Holt, E., 2000b: *Green Pricing Update, 1999*. Electric Power Research Institute, TR-114211, Palo Alto, CA.

Holt, E., and R. Wiser, 1998: *Understanding Consumer Demand for Green Power*. National Wind Coordinating Committee.

Honma, S., 1978: Document 0.25: Was the Muskie standards successful? (in Japanese).

Howarth, R.B., and M. Winslow 1994: Energy Use and Climate Stabilization: Integrating Pricing and Regulatory Policies. *Energy: The International Journal*.

Huber, R.M., J. Ruitenbeek, and R. Serôa da Motta, 1999: Market-Based Instruments for Environmental Policymaking in Latin America and the Caribbean: Lessons from Eleven Countries. World Bank Discussion Paper No. 381, World Bank, Washington, DC.

Hunt, S., and G. Shuttleworth, 1996: *Competition and Choice in Electricity*. John Wiley & Sons, New York, NY.

IEA (International Energy Agency), 1997a: *The directive on the EU electricity market*. IEA, Paris.

IEA, 1997b: *Energy Efficiency Initiative*, Vol. 1. IEA, Paris.

IEA, 1998a: *Energy Policies in IEA Countries*. OECD Publications, Paris.

IEA, 1998b: *World Energy Outlook*. IEA, Paris.

IEA, 1999a: *Electricity Market Reform: An IEA Handbook*. IEA, Paris.

IEA, 1999b: *Looking at Energy Subsidies: Getting the Prices Right. World Energy Outlook*, *1999 Insights*, IEA, Paris.

IPCC, 1996: *Climate Change 1995: Economic and Social Dimensions of Climate Change.* Cambridge University Press, Cambridge, UK

IPCC, 2000: *Special Report on Methodological and Technological Issues in Technology Transfer (SRTT)*. Cambridge University Press, Cambridge, UK.

IPSEP, 1995: Cutting Carbon Emissions: Burden or Benefit? A Summary. In *Energy Policy in the Greenhouse, Volume II*, International Project for Sustainable Energy Paths, El Cerrito, CA.

Iwahashi, T., 1998: Basic Design of a Domestic System of Greenhouse Gas Emissions Trading. *Osaka Law Review*, **48**(3), 857-890.

Jackson, J.H., 2000: Comments on Shrimp/Turtle and the Product/Process Distinction, *European Journal International Law*, **11**(2).

Jacoby, H., and I.S. Wing, 1999: Adjustment time, capital malleability and policy cost. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 73-92.

Jaffe, A.B., and R.N. Stavins, 1995: Dynamic incentives of environmental regulations: The effects of alternative policy instruments on technological diffusion. *Journal of Environmental Economics and Management,* **29,** S43-S63.

Japan Energy Conservation Center, 1997: *Energy Conservation Handbook*, Japan.

Jepma, C.J., 1999: Determining a baseline for project co-operation under the Kyoto Protocol: a general overview. Paper presented at the GISPRI baseline workshop, 25-26 February, Tokyo, Japan.

Jepma, C.J., and W. van der Gaast, (eds.), 1999: *On the Compatibility of Flexibility Instrument*. Kluwer Academic Publishers, Dordrecht.

Jepma, C.J., W. van der Gaast, and E. Woerdman, 1998: *The compatibility of flexible instruments under the Kyoto Protocol.* Dutch National Research Program on Transboundary Global Air Pollution and Climate Change, Paterswolde, Netherlands.

JIQ, 1998: AIJ Pilot Phase: A Mile Wide but only an Inch Deep. *Joint Implementation Quarterly*, **4**(3).

Joskow, P.L., and R. Schmalensee, 1988: The political economy of market-based environmental policy: The U.S. acid rain program. *Journal of Law and Economics,* **41**, 37-83.

Jung, C., K. Krutilla, and R. Boyd, 1996: Incentives for advanced pollution abatement technology at the industry level: An evaluation of policy alternatives. *Journal of Environmental Economics and Management,* **30**, 95-111.

Kainuma, M., Y. Matsuoka, and T. Morita, 1999: Analysis of post-Kyoto scenarios: The Asian-Pacific integrated model. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 207-220.

Kambara, T., 1992: The energy situation in China. *China Quarterly*, **September**, 608-636.

Katsoulacos, Y., and A. Xepapadeas, 1996: Environmental innovation, spillovers and optimal policy rules. In *Environmental Policy and Market Structure*, C. Carraro, Y. Katsoulacos, and A. Xepapadeas, (eds.), pp. 143-150.

Kelman, S., 1981: Cost-Benefit Analysis: An Ethical Critique. *Regulation,* **5**(1).

Kemp, R., and L. Soete, 1990: Inside the "green box:" on the economics of technological change and the environment. *New Explorations in the Economics of Technological Change,* C. Freeman, and L. Soete, (eds.), Pinter, London.

Kennedy, P.W., 1994: Equilibrium pollution taxes in open economies with imperfect competition. *Journal of Environmental Economics and Management,* **27**, 49-63.

Keohane, N.O., 1998: The political economy of environmental policy in Venezuela. Report to the World Bank (Photocopy).

Keohane, N.O., R.L. Revesz, and R.N. Stavins, 1999: The positive political economy of instrument choice in environmental policy. In *Environmental and Public Economics: Essays in Honor of Wallace E. Oates,* A. Panagariya, P.R. Portney, and R.M. Schwab, (eds.), Cheltenham, UK, pp. 89-125.

Kerr, S., 1998: Enforcing Compliance: The Allocation of Liability in International GHG Emissions Trading and the Clean Development Mechanism. Resources for the Future Climate Issue Brief, No 15, October 1998, p4.

Kerr, S., and D. Maré, 1997: Efficient Regulation Through Tradable Permit Markets: The United States Lead Phasedown. Working Paper 96-06, Department of Agricultural and Resource Economics, University of Maryland, MD.

Kete, N., 1992: The U.S. acid rain control allowance trading system. In *Climate Change: Designing a Tradable Permit System*, T. Jones, J. Corfee-Morlot (eds.), Organization for Economic Cooperation and Development, Paris, pp. 69-93.

Kneese, A.V., and C.L. Schulze, 1975: *Pollution, Prices, and Public Policy*. Brookings Institution, Washington, DC.

Kohn, R.E., 1992: When subsidies for pollution abatement increase total emissions. *Southern Economic Journal,* **59**, 77-87.

Kolstad, C.D., 2000: *Environmental Economics*. Oxford University Press, New York, USA and Oxford, UK.

Kooiman, J., 1998: *Topics in the economics of environmental regulation*. Thesis, Tinbergen Institute Research Series, no.182, 141-159, Amsterdam.

Kopp, R., R. Morgenstern, and W. Pizer, 1999a: *Something for everyone: A climate policy that both environmentalists and industry can live with*. Resources for the Future, Washington, DC.

Kopp, R., R. Morgenstern, W. Pizer, and M. Toman, 1999b: A proposal for credible early action in U.S. climate policy. *Weathervane*. Resources for the Future, Washington, DC. [online: http://www.weathervane.rff.org].

Krause, F., 1996: The policy effectiveness of mandatory energy efficiency standards and voluntary agreements: an illustrative case study. In Proceedings of the U.S. Climate Change Analysis Workshop, June 6-7, Springfield, VA., US Environmental Protection Agency, Washington, DC.

Krause, F., E. Haites, R. Howarth, and F. J. Koomey, 1993: Cutting Carbon Emissions: Burden or Benefit? In *Energy Policy in the Greenhouse, Vol. 2, Part 1*. International Project for Sustainable Energy Paths, El Cerrito, CA.

Krause, F., J. Koomey, and D. Olivier, 1998: Low Carbon Comfort: The Cost and Potential of Energy Efficiency in EU Buildings, *Energy Policy in the Greenhouse series, Vol. 2, Part 5.* International Project for Sustainable Energy Paths, El Cerrito, CA.

Kurosawa, A., H. Yagita, Z. Weisheng, K. Tokimatsu, and Y. Yanagisawa, 1999: Analysis of carbon emission stabilization targets and adaptation by integrated assessment model. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 157-176.

Laffont, J.J., and J. Tirole, 1996: Pollution Permits and Environmental Innovation? *Journal of Public Economics*, **62**, 127-140.

Lebo, B., and A. Szabo, 1996*: Preparing minimum energy efficiency standards for European appliances.* Proceedings of International Energy Conference on Use of Efficiency Standards in Energy Policy, Sophia-Antipolis, France, June, IEA/OECD.

Lee, H., and N. Darani, 1995: Electricity Restructuring and the Environment. CSIA Discussion Paper 95-13, Kennedy School of Government, Harvard University, Cambridge, MA.

Legro, S., I. Gritsevich, V. Berdin *et al.*, 1999: *Climate Change Policy and Programs in Russia: An Institutional Assessmen.*.Advanced International Study Unit, PNNL, Washington, DC.

Lile, R., M. Powell, and M. Toman, 1999: Implementing the Clean Development Mechanism: Lessons from U.S. private-sector participation. In Activities Implemented Jointly, Discussion Paper 99-08, Resources for the Future, Washington, DC.

Lora, 1997: A Decade of Structural Reforms in Latin America: What Has Been Reformed and How to Measure It. Document presented at the Annual Meetings of the Inter-American Development Bank, Barcelona.

Lovins, A.B., 1996: Negawatts. Twelve transitions, eight improvements and one distraction. *Energy Policy,* **24**(4), 331-344.

Magat, W.A., 1978: Pollution control and technological advance: A dynamic model of the firm. *Journal of Environmental Economics and Management,* **5**, 1-25.

Magat, W.A., 1979: The effects of environmental regulation on innovation. *Law and Contemporary Problems*, **43**, 3-25.

Maloney, M.T., and R.E. McCormick, 1982: A positive theory of environmental quality regulation. *Journal of Law and Economics* **25**(4), 99-123.

Malueg, D.A., 1989: Emission credit trading and the incentive to adopt new pollution abatement technology, *Journal of Environmental Economics and Management*, **16**, 52-57.

Manne, A.S., and R. Richels, 1999: The Kyoto Protocol: A cost-effective strategy for meeting environmental objectives? *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 1-24.

Matsuo, N., 1998: *How Is the CDM Compatible with Sustainable Development?* The Institute for Global Environmental Strategies (IGES), Japan.

Matsuo, N., 1999: Points and Proposals for the Emissions Trading Regime of Climate Change – For Designing Future System, September.

Markard, J., 1998: *Green Pricing – Welchen Beitrag können freiwillige Zahlungen von Stromkunden zur Förderung regenerativer Energien leisten?* Öko-Institute-Verlag, Freiburg.

McCubbins, M.D., and T. Sullivan, 1984: Constituency influences on legislative policy choice. *Quality and Quantity,* **18**, 299-319.

McKibbin, W.J., and P.J. Wilcoxen, 1997a: Salvaging the Kyoto Climate Change Negotiations. Brookings Policy Brief no. 27, November 1997, The Brookings Institution, Washington, DC.

McKibbin, W.J., and P.J. Wilcoxen, 1997b: A Better Way to Slow Global Climate Change. Brookings Policy Brief no. 17, June 1997, The Brookings Institution, Washington, DC.

McKibbin, W.J., and P.J. Wilcoxen, 2000: The Next Step for Climate Change Policy. Brookings Background Paper #1 (January), Washington, DC.

McKibbin, W., M. Ross, R. Shackleton, and P. Wilcoxen, 1999: Emissions Trading, Capital Flows and the Kyoto Protocol. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 287-334.

McMahon, J., 1992*: Quantifying the benefits and costs of US Appliance energy performance standards.* Proceedings of International Energy Conference on Use of Efficiency Standards in Energy Policy, Sophia-Antipilis. France, 4-5 June 1992, IEA/OECD.

Mestelman, S., 1982: Production externalities and corrective subsidies: A general equilibrium analysis. *Journal of Environmental Economics and Management,* **9**, 186-193.

Michaelowa, A., 2000: Klimapolitik in Großbritannien – Zufall oder gezieltes Handeln? *Zeitschrift für Umweltpolitik und Umweltrecht.*

Michaelowa, A., and M. Dutschke, 1998: Interest groups and efficient design of the Clean Development Mechanism under the Kyoto Protocol. *International Journal for Sustainable Development*, 1(1), 24-42.

Michaelowa, A., and M. Dutschke, 1999a: Economic and Political Aspects of Baselines in the CDM Context. In *Promoting development while limiting greenhouse gas emissions: trends and baselines.* J. Goldemberg, and W. Reid (eds.), New York, NY, pp. 115-134.

Michaelowa, A., and M. Dutschke, 1999b: Creation and sharing of credits through the Clean Development Mechanism under the Kyoto Protocol.. In *On the compatibility of flexible instruments.* C. Jepma, and W. van der Gaast (eds.), Kluwer, Dordrecht, pp. 47-64..

Milliman, S.R., and R. Prince, 1989: Firm incentives to promote technological change in pollution control. *Journal of Environmental Economics and Management,* **17,** 247-265.

Ministry of Economic Affairs, 1997: Long term agreements on energy efficiency progress in 1995, Den Haag, Netherlands.

Mitchell, C., 1995a: Renewables NFFO. *Energy Policy,* **23**(12).

Mitchell, C., 1995b: *Renewable Energy in the UK: Financing Options for the Future*. Council for the Protection of Rural England.

Mitchell, C., 1997: Renewable Non-Fossil Fuel Obligation - The Diffusion of Technology by Regulation. TIP Workshop on Regulation and Innovative Activities, Vienna, February 1997.

Montero, J.P., 1999: Voluntary Compliance with Market-Based Environmental Policy: Evidence from the U.S. Acid Rain Program. *Journal of Political Economy,* **107**(5), 998-1033.

Montero, J.P., 2000a: Optimal design of a phase-in emissions trading program. *Journal of Public Economics*, **75**, 273-291.

Montero, J.P. 2000b: Prices versus quantities with incomplete enforcement. *Journal of Public Economics,*

Montero, J.P., 2000c: Market structure and environmental innovation. Working Paper, Catholic University of Chile (January 21), place.

Montero, J.P., L. Cifuentes, and F. Soto, 2000: Participación voluntaria en políticas internacionales de cambio climático: Implicancias para Chile. *Estudios de Economía.*

Morrisette, P., and A. Plantinga, 1991: The Global Warming Issue: Viewpoints of Different Countries. *Resources,* **103**, 2-6.

Moscow City Government, 1999: *Energy Conservation in Buildings, Requirement for Thermal Performance and Heat-Water-Power Supply*, Moscow.

Mowery, D., and N. Rosenberg, 1989: *Technology and the Pursuit of Economic Growth*. Cambridge University Press, Cambridge, UK.

Murase, S., 1995: Perspectives from International Economic Law on Transnational Environmental Issues. *Recueil des Cours de L'Academie de Droit International de la Haye,* **253**, 283-431.

Murase, S., 1996: Unilateral Measures and the WTO Dispute Settlement. In *Asian Dragon and Green Trade: Environment, Economics and International Law*. S.S.C. Tay, and D.C. Esty (eds.), Times Academic Press, London, pp. 137-144.

Nadel, S., and Geller, H., 1996: Utility DSM. What have we learned? Where are we going? *Energy Policy*, **24**(4), 289-302.

NEDO, 2000: *A Report on Baseline Study Group*. Secretariat. New Energy and Industrial Technology Development Organization (NEDO) and Mitsubishi Research Institute, Tokyo.

Nelson, R.A., T. Tietenberg, and M.R. Donihue, 1993: Differential Environmental Regulation: Effects On Electric Utility Capital Turnover and Emissions. *Review of Economics and Statistics*, **75** (2), 368-373.

Newell, R., and W. Pizer, 1998: Regulating Stock Externalities under Uncertainty. Resources for the Future Discussion Paper 99-10.

Newell, R.G., A.B. Jaffe, and R.N. Stavins, 1999: The induced innovation hypothesis and energy-saving technological change. *Quarterly Journal of Economics* **114**(3), 941-975.

Nordhaus, W.D., and J.G. Boyer, 1999: Requiem for Kyoto: An Economic Analysis of the Kyoto Protocol. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **Ma**y, 93-133.

Novem, 1998: Green Financing. The Netherlands Agency for Energy and Environment, January 28. [online: http://www.novem.org/netherl/green.html].

NRTEE, 1999: *Canada's Options for a Domestic GHG Emissions Trading Program.* National Round Table on the Environment and the Economy, Ottawa, 1999.

Oates, W., and R.M. Schawb, 1988: Economic competition among jurisdictions: Efficiency enhancing or distortion inducing? *Journal of Public Economics,* **35**, 333-354.

OECD, 1978: *Environmental Policies in Japan*. OECD, Paris.

OECD, 1996a: *Implementation Strategies for Environmental Taxes.* OECD, Paris.

OECD, 1996b: *Integrating Environment and Economy: progress in the 1990s.* OECD, Paris.

OECD, 1997a: *Environmental Taxes and Green Tax Reform.* OECD, Paris.

OECD, 1997b: Voluntary Agreements with Industry, Annex I Expert Group on the UNFCCC. Working Paper No.8, OCDE/GD997) 75, Paris [online: http://www.oecd.org/env/cc/freedocs.htm].

OECD, 1997c: *Reforming Energy and Transport Subsidies: Energy and Environmental Implications.* OECD, Paris.

OECD, 1997d: Economic/fiscal instruments: Competitiveness issues related to carbon/energy taxation, Annex I Expert Group on the UNFCCC. Working Paper No.14, OCDE/GD(97)190, OECD, Paris.

OECD, 1998a: *Improving the Environment through Reducing Subsidies, Part I: Summary and Policy Conclusions, and Part II: Analysis and Overview of Studies*. OECD, Paris.

OECD, 1998b: Voluntary Approaches for Environmental Policy in OECD Countries, 21 October, ENV/EPOC (98)6/REV1, OECD, Paris.

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

OECD/IEA, 1997: *Energy Efficiency Initiative. Country Profiles & Case Studies with 47 case studies of successful energy efficiency improvement project and policies implementation to learn from 480.* OECD, Paris.

Owen, G., 1996: *A Market in Efficiency: Providing Energy Savings through Competition.* IPPR.

Oye, K.A., and J.H. Maxwell, 1995: Self-interest and environmental management. In *Local Commons and Global Interdependence: Heterogeneity and Cooperation in Two Domains.* R.O. Keohane, and E. Ostrom, (eds.), Sage Publications, London, pp. 191-221.

Palmer, K., and Burtraw, D., 1997: Electricity restructuring and regional air pollution. *Resource and Energy Economics*, **19**, 139-174.

Panayotou, T., 1998: *Instruments of Change: Motivating and Financing Sustainable Development*. Earthscan Publications and United Nations Environment Program, London.

Parfomak, P., and L. Lave, 1997: How Many Kilowatts are in a Negawatt?. Verifying Ex Post Estimates of Utility Conservation Impacts at the Regional Level. *The Energy Journal*, **17**(4).

Parkinson, S., K. Begg, P. Bailey, and T. Jackson. 1999: JI/CDM crediting under the Kyoto Protocol: does "interim period banking" help or hinder emissions reduction? *Energy Policy*, **27**, 129-136.

Parkinson, S.D., P. Bailey, K. Begg, and T. Jackson, 2000: Accounting for Emissions Reduction and Costs - methodology and case study results, Chapter 7. *Flexibility in Climate Policy: Making the Kyoto Mechanisms Work*. T. Jackson, K. Begg, and S.D. Parkinson, (eds.), Earthscan, UK.

Parry, I.W.H., 1998: Pollution regulation and the efficiency gains from technological innovation. *Journal of Regulatory Economics,* **14,** 229-254.

Parry, I.W.H., R. Williams, and L.H. Goulder, 1999: When Can Carbon Abatement Policies Increase Welfare? – The fundamental role of distorted factor markets. *Journal of Environmental Economics and Management*, **January**.

Patterson, W., 1999: *Transforming Electricity*. The Royal Institute of International Affairs/Earthscan, UK.

Perkins, N. 1999: Introductory Note, World Trade Organization: US-Import Prohibition of Certain Shrimp and Shrimp Products. *International Legal Materials,* **38**, 118-120.

Pezzey, J., 1992: The Symmetry Between Controlling Pollution by Price and by Quantity. *Canadian Journal of Economics,* **25**, 983-991.

Phylipsen, G., K. Blok, and E. Worrel, 1998: *Handbook on International Comparisons of Energy Efficiency in the Manufacturing Industry*. Utrecht, the Netherlands.

Pizer, W.A., 1997a: Optimal choice of policy instrument and stringency under uncertainty: the case of climate change. Resources for the future, report.

Pizer, W.A., 1997b: Prices vs quantities revisited: The case of climate change. Resources for the Future Discussion Paper 98-102.

Pohjola, J., 1999: Economy wide Effects of Reducing CO_2 Emissions: A Comparison between Net and Gross Emissions. *Journal of Forest Economics*, **5**(1), 139-168.

Polenske, K., and X. Lin, 1993: Conserving Energy to Reduce Carbon Dioxide Emissions in China. *Structural Change and Economic Dynamics,* **4**(2).

Poppe, D., 1999: Induced innovation and energy prices. Working Paper, University of Kansas, KS.

Radar, N., 1996: Renewables Portfolio Standard in California as Envisioned by the American Wind Energy Association, American Wind Energy Association (revised May 7, 1996). [online: http://www.igc.apc.org/awea/pol/rpsca.html].

Raekwon, Ch., 1997: Unexplored potential of the public-owned technology for promoting environmentally sound technology transfer. Korean Mission to the UN.

Rasmusen, E., and M. Zupan, 1991: Extending the economic theory of regulation to the form of policy. *Public Choice,* **72**(2-3), 275-96.

Rauscher, M., 1991: Foreign trade and the environment. In *Economics and the Environment: The International Dimension*. H. Siebert,(ed.), Mohr, Tübingen, Germany,

Rauscher, M., 1994: On Ecological Dumping. *Oxford Economic Papers,* **46**, 822-840.

Read, P., 1999: Comparative Static Analysis of Proportionate Abatement Obligations (PAO's) – A Market Based Instrument for Responding to Global Warming. *.NZ Econ Papers,* 33(1), 137-147.

Read, P., 2000: An Information Perspective on Dynamic Efficiency in Environmental Policy. *Information Economics and Policy,* 12(1), 47-68.

Reilly, J., R. Prinn, J. Harmisch, J. Fitzmaurice, H. Jacoby, D. Kicklighter, J. Melillo, P. Stone, A. Sokolov, and C. Wang, 1999: Multiple Gas Assessment of the Kyoto Protocol. *Nature*, **401**, 549-555.

Richards, K., 1998: Framing Environmental Policy Instrument Choice. Working Paper Series, Indiana University, USA.

Roberts, M. J., and M. Spence, 1976: Effluent charges and licenses under uncertainty. *Journal of Public Economics,* **5**, 193-208.

Rose, A., B. Stevens, J. Edmonds, and M. Wise, 1998: International Equity and Differentiation in Global Warming Policy. *Environmental and Resource Economics,* **12**, 25-51.

Rose, A., E. Bulte, and H. Folmer, 1999: Long-Run Implications for Developing Countries of Joint Implementation of GHG Mitigation. *Environmental and Resource Economics,* **14**, 19-31.

Rosen, R., T. Woolf, B. Dougherty, B. Biewald, and S. Bernow, 1995: Promoting Environmental Quality in a Restructured Electric Industry. Prepared for the National Association of Regulatory Utility Commissioners, Tellus Institute, Boston, MA.

Rosewicz, B., 1990: Americans Are Willing to Sacrifice to Reduce Pollution, They Say. *Wall Street Journal*, April 20, A1.

Rowlands, I., 1995: *The politics of global atmospheric change.* Manchester University Press, Manchester, UK.

Rucker, M., 2000: Linking International Green Power Markets: Lessons from the APX Green Tickets. Presented at Fifth National Green Power Marketing Conference, Denver, CO, August 8 2000.

Russell., C. and P. Powell, 1996: *Choosing Environmental Policy Tools Theoretical and Practical Considerations*. Inter American Development Bank, Washington DC.

Sagawa, N., 1998: *Energy in Japan*. The Institute of Energy Economics, March, Japan.

Sandel, M.J., 1997: It's Immoral to Buy the Right to Pollute [Editorial]. *New York Times*, December 15, A29.

Schaeffer, G., M. Boots, J. Martens, and M. Voogt, 1999: *Tradable Green Certificates, A New Market-Based Incentive Scheme for Renewable Energy: Introduction and Analysis*. Netherlands Energy Research Foundation ECN, Petten.

Schmalensee, R., P.L. Joskow, A.D. Ellerman, J.P. Montero, and E.M. Bailey, 1998: An Interim Evaluation of Sulfur Dioxide Emissions Trading. *Journal of Economic Perspectives,* **12**(3), 53-68.

Schneider, K., 1998: Comment on M. Hoel: Emission taxes versus other Environmental Policies. *Scandinavian Journal of Economics,* **100**(1), 105-108.

Schumpeter, J., 1942: *Capitalism, Socialism and Democracy*. Harper, New York, NY..

Segerson, K., and Miceli, T., 1997: Voluntary Approaches to Environmental Protection: The Role of Legislative Threats, Nota di lavoro 21.97, Fondazione Eni Enrico Mattei, Milan.

Shelby, M., R. Shackleton, M. Shealy, and A. Cristofaro, 1997: *The Climate Change Implications of Eliminating U.S. Energy (and Related) Subsidies.* US Environmental Protection Agency, Washington, DC.

Shepsle, K.A., and B.R. Weingast, 1984: Political solutions to market problems. *American Political Science Review,* **78**, 417-34.

Sinton, J.E., and M.D. Levine, 1994: Changing Energy Intensity in Chinese Industry. *Energy Policy,* **March**, 239-255.

Smil, V., 1990: *China's Energy*. Report prepared for the U.S. Congress. Office of Technology Assessment, Washington, DC.

Smith, V.L., and A.W. Williams, 1982: The Effects of Rent Asymmetries in Experimental Auction Markets. *Journal of Economic Behavior and Organization,* **3**(1), 99-116.

Speck, S., 1999: A database of environmental taxes and charges. European Union. (online: http://europa.eu.int/comm/dg11/enveco/).

Stavins, R.N., 1996: Correlated uncertainty and policy instrument choice. *Journal of Environmental Economics and Management*, **30**, 218-232.

Stavins, R.N., 1998a: What Can We Learn from the Grand Policy Experiment? Lessons from SO_2 Allowance Trading. *Journal of Economic Perspectives,* **12**(3), 69-88.

Stavins, R.N., 1998b: *Market Based Environmental Policies*. Kennedy School of Government, Harvard University, Harvard MA.

Stavins, R.N., 2000: Experience with Market-Based Environmental Policy Instruments. *The Handbook of Environmental Economics*. K. Göran Mäler, J. Vincent, (eds.), Elsevier, place.

Stigler, G.J., 1971: The theory of economic regulation. *Bell Journal of Economics and Management Science,* 2, 3-21.

Stoneman, P., 1983: *The Economic Analysis of Technological Change*. Oxford University Press, Oxford, UK.

Storey, M., G. Boyd, and J. Down, 1999: Voluntary Agreements with Industry. In *Voluntary approaches in Environmental Policy.* C. Corraro, and F. Leveque (eds.), Kluwer Academic Publishers, pp. 187-207.

Svendsen, G.T., 1999: U.S. interest groups prefer emission trading: a new perspective. *Public Choice,* **101**(1-2), 109-128.

Swezey, B., and L. Bird, 2000: *Green Power Marketing in the United States: A Status Report.* National Renewable Energy Laboratory, 5th editon. Golden, CO.

TERI, 1997: Capacity building for technology transfer in the context of climate change. TERI (Draft.), New Delhi, India.

TERI, 1998: *Clean Development Mechanism: Issues and Modalities*. TERI, New Delhi, India.

The People's Republic of China, 1997: National Report on Sustainable Development.

Thorne, S., and E.L. La Rovere, 1999: Criteria and indicators for the appraisal of Clean Development Mechanism Projects. Paper presented at COP5, Helio International.

Tietenberg, T., 1998: Ethical influences on the evolution of the US tradable permit approach to air pollution control. *Ecological Economics.* **24**, 241-257.

Tietenberg, T., 2000: *Environmental and Natural Resource Economics*, 5th ed. Addison-Wesley, Reading, MA.

Tietenberg, T., and D. Wheeler, 2000: Empowering the Community: Information Strategies for Pollution Control. In *Frontiers of Environmental Economics,* H. Folmer, (ed.).

Tol, R.S.J., 1999: Kyoto, Efficiency, and Cost-Effectiveness: Application of FUND, *The Energy Journal, Special Issue. The Costs of the Kyoto Protocol: A Multi-Model Evaluation*, **May**, 131-156.

Toman, M.A., R.D. Morgenstern, and J. Anderson, 1999: The economics of when flexibility in the design of GHG abatement policies. Resources for the Future Discussion Paper 99-38 (revised).

Torvanger, A., and Skodvin, T., 1999: *Implementing the Kyoto Protocol - The role of environmental agreements*. CICERO (Center for International Climate and Environmental Research).

Trexler, M., 1998: *The Role of Forestry as a Climate Change Mitigation Strategy.* U.S. Environmental Protection Agency, Washington DC.

Tulpulé, V., S. Brown, J. Lim, C. Polidano, H. Pant, and B.S. Fisher, 1999: The Kyoto Protocol: An Economic Analysis Using GTEM. *The Energy Journal, Special Issue*, *The Costs of the Kyoto Protocol. A Multi-Model Evaluation,* **May,** 257-286.

Ulph, A., 1993: Environmental Policy and International Trade When Governments and Producers Act Strategically. *Journal of Environmental Economics and Management.*

Ulph, A., 1994: Environmental policy, plant location and government protection. In *Trade, Innovation, Environment*. C. Carraro, C. (ed.), Kluwer, Dordrecht.

Ulph, A., 1996: Strategic environmental policy and international trade - the role of market conduct. In *Environmental Policy and Market Structure.* C. Carraro, Y. Katsoulacos, and A. Xepapadeas, (eds.), pp. 99-127.

Ulph, D., 1994: Strategic innovation and strategic environmental policy. In *Trade, Innovation, Environment*. C. Carraro (ed.), Kluwer, Dordrecht.

UNCTAD, 1998: *Greenhouse Gas Emissions Trading: Defining the Principles, Modalities, Rules and Guidelines for Verification, Reporting and Accountability.* United Nations, p.15., August.

UNEP, 1983; 1991: Multilateral Treaties in the Field of the Environment, Vol. 1 (1983), Vol. 2 (1991).

UNFCCC, 1992: *United Nations Framework Convention on Climate Change*. Climate Change Secretariat, Geneva, June.

UNFCCC, 1997: *The Kyoto Protocol to the Convention on Climate Change*. Climate Change Secretariat, Bonn, December.

UNFCCC, 1999: Procedures and mechanisms relating to compliance under the Kyoto Protocol. Submissions from Parties, Note by the secretariat, United Nations (FCCC/SB/1999/MISC.4 and addenda).

UNFCCC, 2000: Procedures and mechanisms relating to compliance under the Kyoto Protocol. Proposals by the Co-Chairman of the Joint Working Group on Compliance, 15 September.

United Kingdom of Great Britain and Northern Ireland, 1998: Non-Paper on Principles, Modalities, Rules and Guidelines for an International Emissions Trading Regime on behalf of the European Community and its Member States and Czech Republic, Slovakia, Croatia, Latvia, Switzerland, Slovenia, Poland and Bulgaria, June 8.

US Congressional Record, 1992: The Comprehensive National Energy Policy Act, Vol. 138, No. 142-Part V, Washington, DC.

US DOE, 1999: *Supporting Analysis of the Clinton Administration's Comprehensive Electricity Act (CECA).* US DOE, May.

US FERC, 1996: Environmental Impact Statement, Promoting Wholesale Competition through Open Access Non-Discriminatory Transmission Services by Public Utilities and Recovery of Stranded Cost by Public Utilities and Transmitting Utilities, US FERC, April.

Van Beers, C. and Van den Bergh, 1997: An empirical multi-country analysis of the impact of environmental regulations on foreign trade flows. *Kyklos* **50**, 29-46.

Van Dril, A.W.N., 2000: *Testing Dutch LTA's: eco-efficiency can be improved.* ENER.

Vollebergh, H.R.J., J.L. de Vries and P.R. Koutstaal, 1997: Hybrid carbon incentive mechanisms and political acceptability. *Environmental and Resource Economics* **9**, 43-63.

Ward, H. and D. Black, 2000: Trade, Investment and the Environment, The Royal Institute of International Affairs, London.

Watson, W.D. and R.G. Ridker, 1984: Losses from effluent taxes and quotas under uncertainty. *Journal of Environmental Economics and Management* **11**, 310-316.

WEC, 1998: *Benefits and Deficiencies of Energy Sector Liberalization.* World Energy Council.

Weinberg, C.J., 1995: The Electricity Utility: Restructuring and Technology - A Path to Light or Dark. In *Profits in the Public Interest.* National Association of Regulatory Utility Commissioners. Washington DC.

Weitzman, M., 1974: Prices versus quantities. *Review of Economic Studies* **41**, 477-491.

Wellisch, D., 1995: Locational choices of firms and decentralized environmental policy with various instruments. *Journal of Urban Economics* **37**(3), 290-310.

Werksman, J., 1998: Compliance and the Kyoto Protocol: Building a Backbone into a "Flexible" Regime. *9 Yearbook International Environmental Law*, **48.**

Werksman, J., 1999: *GHG Emissions Trading and the WTO*. Foundation for International Law and Development, London.

Weyant, J.P., and J. Hill, 1999: Introduction and Overview. *The Energy Journal, Special Issue, The Costs of the Kyoto Protocol: A Multi-Model Evaluation,* **May,** vii-xiv.

Wiener, J., 1998: Global Environmental Regulation: Instrument Choice in Legal Context. *Yale Law Journal,* **677**, 108.

Wirl, F., C. Huber, and I.O. Walker, 1998: Joint Implementation: Strategic Reactions and Possible Remedies. *Environmental and Resource Economics*, 12(2), 203-224.

Wiser, G., 1999: *Compliance Systems Under Multilateral Agreements.* Centre for International Environmental Law, Washington, DC., October.

Wiser, G., 2000: *Restoring the Balance, Using Remedial Measures to Avoid and Cure Non-Compliance under the Kyoto Protocol*, March.

Wiser, R.H., 1997: Renewable energy finance and project ownership: the impact of alternative development structures on the cost of wind power. *Energy Policy*, **25**(1), 15-27.

Wiser, R. 1999. *Comparing State Portfolio Standards and System-Benefits Charges Under Restructuring*. LBNL, April.

Wiser, R., and S. Pickle, 1997: *Green Marketing, Renewables and Free Riders: Increasing Customer Demand for Public Good.* Lawrence Berkeley National Laboratory, Berkeley, CA, LBNL-40532, UC-1321, September.

Wiser, R., J. Fang, and A. Houston, 1999: *Green Power Marketing in Retail Competition: An Early Assessment.* The Topical Issues Brief Series sponsored by DOE's Office of Energy Efficiency and Renewable Energy, place.

Wiser, R., K. Porter, and M. Bolinger, 2000: *Comparing State Portfolio Standards and System-Benefits Charges Under Restructuring.* Lawrence Berkeley National Laboratory. Berkeley, CA.

Woerdman, E., 2000: *The EU Proposal on Supplementarity: a Questionnaire.* University of Groningen, Groningen, The Netherlands.

Woerdman, E., and W.P. van der Gaast, 1999: A Review of the Cost-Effectiveness of Activities Implemented Jointly: Projecting JI and CDM Credit Prices. ECOF Working Paper (First Draft), University of Groningen, Groningen, The Netherlands.

Wolsink, M., 1996: Dutch Wind Power Policy: Stagnating Implementation of Renewables. *Energy Policy*, **24**(12).

World Trade Organization, 1999: *United States- Import Prohibition of Certain Shrimp and Shrimp Products (Shrimp-Turtle decision).* Report of the Appellate Body (WT/DS58/AB/R), 12 October.

Wortmann, K., M. Klitzke, S. Lörx, R. Menges, 1996: Grüner Tarif. Klimaschutz durch freiwillige Kundenbeiträge zum Stromtarif. Akzeptanz, Umsetzung, Verwendung. Energiestiftung Schleswig-Holstein Studie 2, Kiel, Germany.

Yamaguchi, M. 2000. *Global Environmental Issues and Corporate Activity*. Iwanami Publishing Company. Tokyo (in Japanese).

Yamin, F., 1998: The Clean Development Mechanism and Adaptation, Working Paper, Foundation for International Environmental Law and Development, London, p. 38.

Yamin, F, J. Burniaux, and A. Nentjes, 2000: Kyoto Mechanisms: Key Issues for Policy-Makers for COP-6. *International Environmental Agreements: Politics, Law and Economics*, **1**(2).

Zerbe, R.O., 1970: Theoretical efficiency in pollution control. *Western Economic Journal,* **8,** 364-376.

Zhang, Z., 1999a: Estimating the Size of the Potential Market for All Three Flexibility Mechanisms under the Kyoto Protocol.

Zhang, Z., 1999b: Towards a Successful International GHG Emissions Trading System. *On the Compatibility of Flexible Instruments*. C.J. Jepma, W. van der Gaast (eds.), Kluwer Academic Publishers, Dordrecht, pp. 93-102.

Zhang, Z., 2000: Should the rules of allocating permits be harmonized? *Ecological Economics.*