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Environmental
Law & Policy
Forum

REDUCING GREENHOUSE GASES: A COMBINED STRATEGY USING FEES, PERMITS, AND COUNTRY COMMITMENTS

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Volume III 1993

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INTRODUCTION

In June 1992, over 150 nations signed the United Nation's Framework Convention on Climate Change (Climate Convention).[1] The Convention's objective, to stabilize concentrations of greenhouse gases "at a level that would prevent dangerous anthropogenic interference with the climate system,"[2] will require many countries to reduce their emissions of greenhouse gases (GHGs) far below present levels.[3] As negotiators and commentators have considered mechanisms for implementing the Climate Convention, three basic regimes for limiting GHG emissions have come under scrutiny: (1) country commitments;[4] (2) international emissions fees;[5] and (3) international marketable permits.[6] Each regime has strengths and weaknesses which must be evaluated and combined into a strategy implementing the strengths and mitigating or avoiding the weaknesses of each.

The principle source of anthropogenic (human-induced) GHG emissions is the burning of fossil fuels for energy and transportation in industrial countries.[7]

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* This paper is intended to spark discussions about the combined strategy. All comments and refinements are welcome.

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1. UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE, JUNE 12, 1992, S. TREATY DOC. No. 38, 102d Cong., 2d Sess. (1992) [hereinafter CLIMATE CONVENTION].

2. *Id.* art. 2.

3. It has been estimated that to stabilize atmospheric concentrations of CO_2, the most important GHG, at current levels would require a 60–80% reduction from current emission levels. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE: THE IPCC SCIENTIFIC ASSESSMENT 18 (1990) [hereinafter IPCC SCIENTIFIC ASSESSMENT].

4. The term "country commitments" is used in this article to refer to a combination of technology-based standards and "targets and timetables." *See infra* notes 15-17 and accompanying text.

5. INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE, CLIMATE CHANGE: THE IPCC RESPONSE STRATEGIES 240–41 (1991) [hereinafter IPCC RESPONSE STRATEGIES].

6. *Id.*

7. WORLD RESOURCES INSTITUTE, WORLD RESOURCES 1992–93, at 346–49 (1992) [hereinafter WRI 92–93]. As used in this paper the term "industrial countries" includes the so-called "transitional economy" countries of Central and Eastern Europe and the former Soviet Union.

Although industrial countries have only about one-fourth of the world's population,[8] they account for nearly seventy-five percent of the world's consumption of fossil fuels[9] and more than two-thirds of industrial and energy-based emissions of carbon dioxide (CO_2),[10] the principle GHG.[11] Therefore, solving the problem of global warming through reduced GHG production means, first and foremost, reducing fossil fuel use in industrial countries.

Two additional problems face any effort to reduce GHG production worldwide. First, the international community must equitably address the growing demand for energy in developing countries. If no constraints are imposed, energy use in developing countries will continue to increase and may eventually surpass energy use in industrial countries.[12] Second, the international community must decrease the rate of deforestation. Arresting the rapid rate of deforestation[13] is necessary not only for climate protection, but also for species protection, soil conservation, and other important environmental issues. Every year huge tracts of forest are cut or burned, releasing vast quantities of CO_2 into the atmosphere.[14]

This article proposes a strategy for reducing GHG emissions in industrial countries, limiting the growth of emissions in developing countries, and reducing or eliminating deforestation. By combining the most useful elements of country commitments, international emissions fees, and international marketable permits, these three goals may be achieved. Part I of this article describes the three basic regimes and the central problems any successful regime must address. The proposed strategy, entitled "combined strategy," is described in Part II. It consists of two components: an emissions control mechanism and a financial mechanism. Part III evaluates this strategy in terms of specific criteria: costs, effectiveness, fairness, political acceptability, innovation and diffusion of technology, and administration and monitoring. Finally, Part IV explores, by way of example, how the strategy would work given some specific goals and assumptions.

I. THE THREE BASIC REGIMES

A. Country Commitments

The first regime, country commitments, would require that parties to the Climate Convention reduce emissions of GHGs by meeting performance-based

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8. David Pearce, *Population Growth, in* BLUEPRINT 2: GREENING THE WORLD ECONOMY 109, 110 (David Pearce ed., 1991).

9. WRI 92–93, *supra* note 7, at 315–317.

10. *Id.* at 346–47.

11. IPCC SCIENTIFIC ASSESSMENT, *supra* note 3, at 7.

12. *See* IPCC RESPONSE STRATEGIES, *supra* note 5, at 35.

13. Ed Barbier, *Tropical Deforestation, in* BLUEPRINT 2: GREENING OF THE WORLD ECONOMY, *supra* note 8, at 138, 140–41.

14. IPCC RESPONSE STRATEGIES, *supra* note 5, at 87.

standards, often referred to as "targets and timetables,"[15] or technology-based standards, such as "best available control technology."[16] To the extent that they specify each country's emission reduction goals or strategy for reducing emissions, country commitments are similar to U.S. command-and-control environmental regulations. Command-and-control regulations, however, are slowly giving way to less costly, more flexible, market-based approaches, like emissions fees and marketable permits.[17]

B. Emissions Fees

Under the second regime, emissions fees would be charged to governments according to the amount of GHGs their country emits.[18] Alternatively, they could be levied directly on polluters or producers of GHGs. As fees increase, emissions become more costly and the incentive to reduce becomes greater.

C. Marketable Permits

The third regime proposes that international marketable permits be allocated to countries or individual polluters to allow emissions of specified amounts of GHGs.[19] A global emissions cap would be set by the number of permits allocated. Polluters would have the option of selling or trading their permits to other polluters with higher marginal abatement costs. Over time, the number of permits in circulation would be reduced by agreement until the target level of global emissions is reached.

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15. The Montreal Protocol on Substances that Deplete the Ozone Layer relied on targets and timetables to control emissions of chloroflorocarbons (CFCs). Industrial country parties initially committed to reduce consumption of CFCs by 50% by the year 2000. Montreal Protocol on Substances that Deplete the Ozone Layer, Final Act, Sept. 16, 1987, 26 I.L.M. 1541, 1552 (1987). Subsequently, these targets and timetables were strengthened to require a complete phaseout by 1996. Report of the 4th Meeting of the Parties to the Montreal Protocol, Nov. 25, 1992, U.N. Doc. UNEP/OzLPro.4/15, annex 1 (1992).

16. In the U.S., "best available control technology" refers to strict emissions standards requiring sources to install control technology so as to achieve "the maximum degree of reduction possible." Clean Air Act, 42 U.S.C. § 7479(3) (1990).

17. TOM TIETENBERG, ENVIRONMENTAL AND NATURAL RESOURCE ECONOMICS 419 (2d ed. 1988). Country commitments would not prevent individual countries from adopting a national system of marketable permits or emission fees. Such an approach would have many of the advantages of the international scheme but would not be as cost-effective in the long run. This national approach will not be considered in this article.

18. IPCC RESPONSE STRATEGIES, *supra* note 5, at 240-41.

19. *Id.* at 240-41.

II. THE PROPOSAL: A COMBINED STRATEGY

A. Framework

The framework of the combined strategy has two primary components:

(1) An emissions control mechanism that would include:

(a) an international marketable permit system for controlling emissions, with permits allocated initially on the basis of past emissions but converging exponentially to an equal per capita distribution at a reduced global level;[20] *and*

(b) country commitments to (i) use "best available control technology" to reduce emissions of greenhouse gases from sources not amenable to control by market mechanisms, and (ii) adopt targets and timetables to phase out deforestation.

(2) A financial mechanism that would establish:

(a) an abatement fund financed from unallocated emission permits to provide financial and technical assistance to countries seeking to reduce their emissions; and

(b) a damage fund financed from sliding-scale emissions fees to cover the "external" costs of GHG emissions, including: costs of avoiding, repairing and mitigating damage resulting from global warming; insurance costs for highly vulnerable states; and costs of administering the climate agreement.

B. The Emissions Control Mechanism

1. International Marketable Permits[21]

The central feature of the proposed emissions control mechanism is a system of international marketable permits. To implement such a system, a global emissions target, a date for meeting that target, and a global emissions reduction schedule must be selected.[22] In addition, the amounts and periods of permit allocations must be specified. In the proposed strategy, one year's worth of permits would be allocated each year. In the first year, countries would receive permits equal to their historical level of annual emissions. In the second year, and each year thereafter, the allocation would be adjusted downward to meet a target of reduced global emissions, eventually to converge in the target year at a common per capita level. Countries with per capita emissions currently above the target level would have their per capita allocation

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20. *See* JOSHUA M. EPSTEIN & RAJ GUPTA, CONTROLLING THE GREENHOUSE EFFECT: FIVE GLOBAL REGIONS COMPARED 8–15 (1990).

21. *See* IPCC RESPONSE STRATEGIES, *supra* note 5, at 240-41.

22. For example, linear reductions or exponential reductions could be chosen.

reduced. Countries with per capita emissions below the target level would have their allocation increased.

2. Country Commitments[23]

Countries will have to commit to take specific action limiting emissions of GHGs from sources that presently cannot be regulated by market mechanisms. In order to impose emissions fees on a source, emissions must be quantifiable. Permit trading requires not only that emissions be quantifiable but also that they can be maintained at or below a specified level. Not all sources meet these criteria. For example, methane emissions from livestock and rice paddies and nitrous oxide emissions from denitrification of fertilizers can be neither easily counted nor controlled.[24] Until such emissions become quantifiable, country commitments to use best available control technology should be the most workable approach to restricting emissions from these sources.

Country commitments to eliminate deforestation will also be needed. Permits can provide an incentive to phase out deforestation ahead of schedule and to help compensate countries for costs incurred in reducing or eliminating deforestation. Because permits alone cannot guarantee that deforestation will be eliminated, or even reduced, countries should also commit to targets and timetables to phase out deforestation.

C. The Financial Mechanism

1. Abatement Fund

Developing countries will need technical and financial assistance to fulfill their commitments to control emissions.[25] A marketable permit system would allow countries with low per capita emissions to sell or trade excess permits for technology or other forms of assistance. There is no guarantee, however, that developing countries would use the proceeds of their permit sales to address global warming. Unless the same limitation were imposed on the more industrialized countries, however, it would be unfair to require developing countries to invest in new technologies or other GHG abatement programs. Therefore, some unallocated permits should be held in an internationally administered abatement fund to finance technology transfers and other costs of controlling emissions. The fund would provide grants and concessional loans, with the level of assistance based on the recipient country's ability to pay. Ability to pay could be based on per capita income.

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23. *See supra* notes 15-17 and accompanying text.

24. IPCC RESPONSE STRATEGIES, *supra* note 5, at 110–11; IPCC SCIENTIFIC ASSESSMENT, *supra* note 3, at 29; U.S. ENVIRONMENTAL PROTECTION AGENCY, POLICY OPTIONS FOR STABILIZING GLOBAL CLIMATE II–14 (1990).

25. William R. Cline, *Global Warming: The Economic Stakes*, POL'Y ANALYSES INT'L ECON, May 1992, at 1, 83 (estimating that resource flows to developing countries for control of GHGs will require on the order of $5 billion to $10 billion annually).

2. Damage Fund

In accordance with the "polluter pays principle,"[26] the costs of repairing, adapting to, or avoiding damage from global warming—other than by abating emissions—should be borne by polluters in proportion to their contribution to global warming. It would be inconsistent with the polluter pays principle to pay these remediation and adaptation costs out of the abatement fund, because this would require all countries to pay irrespective of their contribution to total GHG emissions. Therefore, a second fund would be needed to cover the external costs of GHG emissions, including the costs of mitigating or adapting to damage, insuring vulnerable states, and administering the climate agreement. In keeping with the polluter pays principle, the fund would be financed from sliding-scale emissions fees. As a country's emissions rise, the fee on each additional unit of pollution would increase as well. Because marginal damage costs are expected to increase as the buildup of GHGs increases,[27] the proportion of total damage caused by countries with high per capita emissions is greater than their proportion of global GHG emissions. Thus, as countries' per capita emissions increase, their "marginal tax rate" should increase.

III. EVALUATION OF THE PROPOSED COMBINED STRATEGY

This section discusses the combined strategy in terms of costs, effectiveness, fairness, political acceptability, innovation and diffusion of technology, and administration and monitoring.

A. Costs

Market mechanisms, such as emissions fees or marketable permits, can achieve a given level of pollution reduction at a lower cost than direct command-and-control regulation. They accomplish this by allocating abatement obligations to those who can achieve them at the lowest cost.[28] With market-based schemes, polluters are given the choice of abating their emissions or incurring the cost of a fee or permit to continue emitting. Presumably they will choose whichever is cheaper. The market creates conditions which equalize

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26. ORGANIZATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT COUNCIL, RECOMMENDATION ON THE IMPLEMENTATION OF THE POLLUTER-PAYS PRINCIPLE, Nov. 14, 1974, OECD Doc. C(74)223, 14 I.L.M. 234 (1974).

27. This is clear if one considers the likely consequences of extreme warming; for example, melting of polar ice caps could result in a sea level rise of 6 to 7 meters. Gjerrit P. Hekstra, *Sea Level Rise: Regional Consequences and Responses, in* GREENHOUSE WARMING: ABATEMENT AND ADAPTATION, 53, 55 (1989).

28. *See generally* Daniel J. Dudek & John Palmisano, *Emissions Trading: Why Is This Thoroughbred Hobbled?*, 13 COL. J. ENVTL. L. 217 (1988); Robert W. Hahn, *Economic Prescriptions for Environmental Problems: How the Patient Followed the Doctor's Orders*, J. ECON. PERSP., Spring 1989, at 95, 98 (marketable permits and emissions charges induce businesses to search for lower cost methods of achieving environmental standards); Tom H. Tietenberg, *Economic Instruments for Environmental Regulation*, 6 OXFORD REV. ECON. POL'Y 17 (1990).

marginal abatement costs for all polluters. Those with lower abatement costs will eliminate their emissions while those with higher abatement costs will purchase permits or pay the fees necessary to continue to pollute.[29] Individual countries, particularly the United States, have implemented national marketable permit schemes to control pollution at reduced costs.[30] However, because some countries are able to reduce emissions less expensively than others, even greater savings could be achieved if the market were to operate internationally.

The market approach, however, may not work as well in practice as in theory. Polluters may lack information about abatement technologies, face significant transaction costs, not have ready access to permit markets, or fail to respond to market incentives. Nevertheless, experience with market mechanisms indicates that real world savings can be achieved.[31]

B. Effectiveness

While both emissions fees and marketable permits would promote cost-effective reductions in GHGs, they may not be equally effective in preventing damage to the atmosphere caused by GHG emissions. With marketable permits, as with country commitments, regulators specify the level of emissions (for example, seven billion tons of carbon in 2000) and must predict the marginal costs of implementation. With emissions fees, regulators specify the marginal cost of abatement (for example $50 per ton of carbon), but can only guess at the resulting level of emissions reduction. Given that the primary goal of regulating greenhouse gases is to protect humans from potentially serious environmental damage, the more prudent approach would be to use marketable permits set at levels considered safe according to the best available scientific understanding.[32]

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29. For example, in a world consisting of two polluters, where one can reduce emissions by one unit at a cost of $1000 and another can reduce emissions by one unit for $500, requiring both polluters to reduce by one unit would cost $1500. However, if pollution allowances are traded, the polluter with the higher cost would be willing to pay its lower-cost counterpart $500 to reduce by two units. The total cost, then, for the same two units of abatement is only $1000. In this way the market achieves a cost-effective distribution, i.e., one in which marginal costs of pollution reduction are the same for all polluters. *See generally* WILLIAM J. BAUMOL & WALLACE E. OATES, THE THEORY OF ENVIRONMENTAL POLICY (2d ed. 1988) (discussing cost-effective approaches to environmental regulation).

30. Anil Markandya, *Global Warming: The Economics of Tradeable Permits, in* BLUEPRINT 2: GREENING THE WORLD ECONOMY, *supra* note 8, at 53, 60.

31. *See, e.g.*, HAHN, *supra* note 28, at 100 (estimating aggregate lifetime savings of $25 million to $300 million in permitting costs and $500 million to $12 billion in emission control costs for various emissions trading programs under the Clean Air Act).

32. A particular concern is that there may be threshold effects from global warming, i.e., that severe damage could result once certain levels of greenhouse gas concentrations are reached. *See, e.g.*, Wallace S. Broecker & George H. Denton, *What Drives Glacial Cycles?*, SCI. AM., Jan. 1990, at 49, 56.

Furthermore, the permit approach is similar to the decisionmaking regulators engage in under traditional performance-based command-and-control regimes. Like command-and-control regulations, marketable permit regimes begin with the setting of a desired emissions level. Permits merely provide a mechanism to implement selected levels of protection in a more cost effective manner.[33] Regulators may select the same level of protection under permits as they would under a command-and-control regime, or, knowing that permits will make implementation less expensive for polluters, they may choose a more stringent level.[34]

C. Fairness

Any solution to global warming must reconcile the differences between industrial and developing countries' interests in allocating the earth's capacity to assimilate GHGs. Industrial countries may feel that because they have built up their economies in reliance on a certain level of emissions, they are entitled to continue to use their historical proportion of the atmosphere. On the other hand, developing countries might argue that industrial countries have already used their share and what remains belongs principally to the developing countries.[35] The strategy offered here is a compromise. Marketable permits would be allocated initially on the basis of historical emissions levels, but would converge to a common per capita allocation at a greatly reduced level. The approach would respond to each country's concerns regarding fairness, while providing protection against global warming.

Because of the rapid rate of growth in their GHG emissions, it is crucial that developing countries participate in an emissions abatement regime. Developing countries, however, are not likely to use their own scarce resources to control their emissions. They argue that the industrial world achieved its high standard of living largely by disregarding such environmental hazards, and further note that their per capita emissions are only a small fraction of industrial country per capita emissions, which they view largely as "luxury emissions."[36] If developing countries receive permits in excess of their actual emissions, as this strategy

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33. To convert from technology-based command-and-control regulations to performance-based marketable permits, regulators would have to calculate the emissions levels resulting from the existing technology standards, substitute an equivalent performance standard, and issue permits for the amount of allowed pollution.

34. In fact, this is the approach taken in the CFC trading provisions in the Clean Air Act, which requires that trades result in lower emissions than would occur otherwise. 42 U.S.C. § 7671f(a) (1992). *See also* Joseph J. DiMona, The Role of Emissions Allowance Trading in the Reduction of Greenhouse Gases (1991) (Working Paper on Technology and Global Change, No. 4, on file at Center for International Environmental Law, Washington D.C.).

35. *See* ANIL AGARWAL & SUNITA NARAIN, GLOBAL WARMING IN AN UNEQUAL WORLD 2 (1991).

36. *Id.* at 5; David Batker, *The Rift Between North and South Over Development and Finances*, AMERICA, May 23, 1992, at 458, 458.

contemplates, they could exchange the excess permits for state-of-the-art, highly efficient technology, which would improve their competitiveness and reduce their emissions.

Countries must also decide how to distribute the many other costs of responding to global warming. Countries whose per capita emissions do not exceed the earth's absorptive capacity should not be required to pay for adaptation, mitigation and other external costs. Moreover, marginal damage increases as the atmospheric concentration of GHGs increases. Thus, the damage caused by large polluters is disproportionately greater than the damage caused by small polluters. A properly structured emissions fee should address these issues by taxing only per capita emissions which exceed the level of per capita emissions that the earth can absorb and by increasing as per capita emissions increase.

D. Political Acceptability

Industrial countries will prefer strategies that minimize disruption to their economies. A permit scheme that gradually shifts from an allocation based on historical levels of emissions to common per capita emissions would provide time to adjust their economies, develop new technologies, and implement strategies for reducing emissions.

A permit allocation converging at a common per capita level would appeal to developing countries because they would receive a net resource transfer. Industrial countries would prefer to avoid such a transfer, but recognize that a global warming agreement will not be effective unless it addresses the projected rapid growth in developing country emissions. They know that developing countries will not substantially reduce their rate of emissions growth without assistance and accept that some form of resource transfer will be needed.[37] To the extent that there is a correlation between damage from global warming and gross domestic product, industrial countries also have more to gain from abatement than developing countries.

E. Innovation and Diffusion of Technology

By providing a continuing incentive to reduce emissions, both emissions fees and marketable permits would stimulate the development of innovative technologies. Permits would also promote the diffusion of such technologies by encouraging firms in industrial countries to transfer abatement technologies to firms in developing countries in exchange for permits. In particular, such firm to firm trading could promote the transfer of vital "soft" technology, such as technical training.

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37. Indeed, the inclusion of a financial mechanism "for the provision of financial resources on a grant or concessional basis, including the transfer of technology" in the Climate Convention shifts the question from whether to have a resource transfer to how large should the transfer be; *see* CLIMATE CONVENTION, *supra* note 1, art. 11.

Developing countries are particularly concerned that they may not have access to, or be able to afford, state-of-the-art technologies protected by intellectual property rights. As a result, they have insisted that industrial countries ensure that technology be transferred on a preferential or non-commercial basis.[38] Industrial countries have, thus far, resisted these demands, arguing that in free market countries the government does not own the technology and therefore cannot agree to transfer it.[39] As a possible solution to this problem, the role of the abatement fund could be expanded to allow it to purchase technology, in particular patents and licenses, to be transferred to developing countries on favorable terms. Because the abatement fund would be financed with permits, which are sensitive to the rise and fall of abatement costs, the assets available to the fund for technology purchase would also rise and fall with the price of technology. If high technology costs raise the cost of abatement, permit prices will go up and the fund's assets will increase. Similarly, low technology costs will reduce not only the fund's assets, but also the need for those assets. Using the abatement fund to invest in abatement technology could also lower the price of permits, perhaps substantially, both by stimulating research and development and by subsidizing the cost to polluters of abatement.[40]

The abatement fund could also serve as a clearinghouse to collect and disseminate technical information, identify and promote projects, conduct pre-investment studies, oversee project construction, provide training, and monitor operations. It could administer and facilitate permit trading, link buyers and sellers, evaluate trades, and verify reductions.

F. Administration and Monitoring

Ease of administration is one reason to prefer emissions fees over marketable permits. Emissions fees are easy to administer because they can be levied at the source. For example, fossil fuel producers could be charged a carbon tax, which they would pass on to polluters. In contrast, because of the direct link between abatement costs and permit prices, permits would have to be held and traded by polluters. Since there are many more polluters than producers, administration would be correspondingly more difficult.

The problem presented when producers hold permits is that the efficiency of permit trading derives from the direct link between permit prices and abatement costs. Polluters know the cost of reducing emissions and, therefore, know what a permit is worth. Producers have no similar mechanism to inform

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38. IPCC RESPONSE STRATEGIES, *supra* note 5, at 226.

39. *Id.*; *see also* UNITED NATIONS, DEP'T OF PUBLIC INFORMATION, EARTH SUMMIT IN FOCUS NO. 3, U.N. Doc. DPI/1161 (Sept. 1991).

40. Studies have shown that direct investment of the proceeds from a carbon tax in abatement could lower the level of tax required by an order of magnitude. FLORENTIN KRAUSE ET AL., ENERGY POLICY IN THE GREENHOUSE, vol. 2, Draft Final Report, at II.3.11 (1992) (on file with author).

them of the correct "market clearing" price for permits. The problem of monitoring is not insurmountable, however. Emissions in a permit system could be monitored at the stack or at the pump, since the amount of fuel consumed determines the amount of GHGs emitted.

Another problem associated with international permit trading is that, while emissions fees or country commitments require only national monitoring, international trades would require cross-border verification. This difficulty gives rise to the danger that emission reductions in countries with effective monitoring mechanisms will be offset by increases in countries lacking such mechanisms. Thus, there should be a mechanism, preferably at the international level, for evaluating international trades. As noted above, this may be a role for the abatement fund. Permit trades that cannot be adequately monitored should not be approved. The burden should be on the trading parties to demonstrate, and if necessary provide the means for, effective monitoring.

IV. Implementing the Combined Strategy

The following section illustrates how the combined strategy would work given certain specific assumptions. For simplicity, the emissions scheme discussed here will be for CO_2 only. Of all GHGs, CO_2 is the easiest to monitor and control, and accounts for more than half of human-induced global warming.[41]

A. The Global Emissions Cap

For the purposes of the proposed strategy, assume negotiators decide to reduce 1995 global carbon emissions levels by forty-five percent by the year 2025. Assuming a 1995 carbon emissions baseline of 7.7 billion tons (gigatons or Gt),[42] the target of a forty-five percent reduction by 2025 could be achieved by reducing global emissions, or total permit allocations, by 0.12 Gt per year.

B. Permit Allocations

Permits would be allocated annually as follows:

(1) The year 2025 would be the target for permits to be distributed on an equal per capita basis. A permit allocation in 2025 of 0.5 tons of carbon per capita per year would result in annual global emissions of 4.2 Gt of carbon, fifty-five percent of the 1995 baseline amount.

(2) Beginning in 1995, and each year thereafter, a year's worth of emissions permits would be allocated to all countries based on their previous year's energy-related emissions, adjusted by an annual percentage increase or decrease, so that by the year 2025 an allocation of 0.5 tons of carbon per capita

41. IPCC Scientific Assessment, *supra* note 3, at 7.
42. WRI 92–93, *supra* note 7, at 346–49 (based on 1995 population projections).

would be achieved in all countries. To avoid giving countries an incentive to increase their populations in order to receive more permits, each country's 2025 population would be estimated in advance.[43]

The percentage annual adjustments to permit allocations that would be required of several countries are given in Table 1. While the industrial countries' rate of decrease may seem high, their rate of actual abatement would probably be much lower because they could purchase additional permits from developing countries.

Table 1[44]

Country	Annual Abatement
U.S.	-7.4%
Germany	-6.1%
Poland	-5.7%
U.K.	-5.5%
Japan	-5.1%
Mexico	-0.9%
China	0.2%
Brazil	1.3%
India	4.3%

C. The Financial Mechanism

1. Abatement Fund

Because the allocation scheme suggested above reduces global emissions in a straight line while adjusting permit allocations exponentially (more akin to natural growth or decline), it creates a pool of unallocated permits during the

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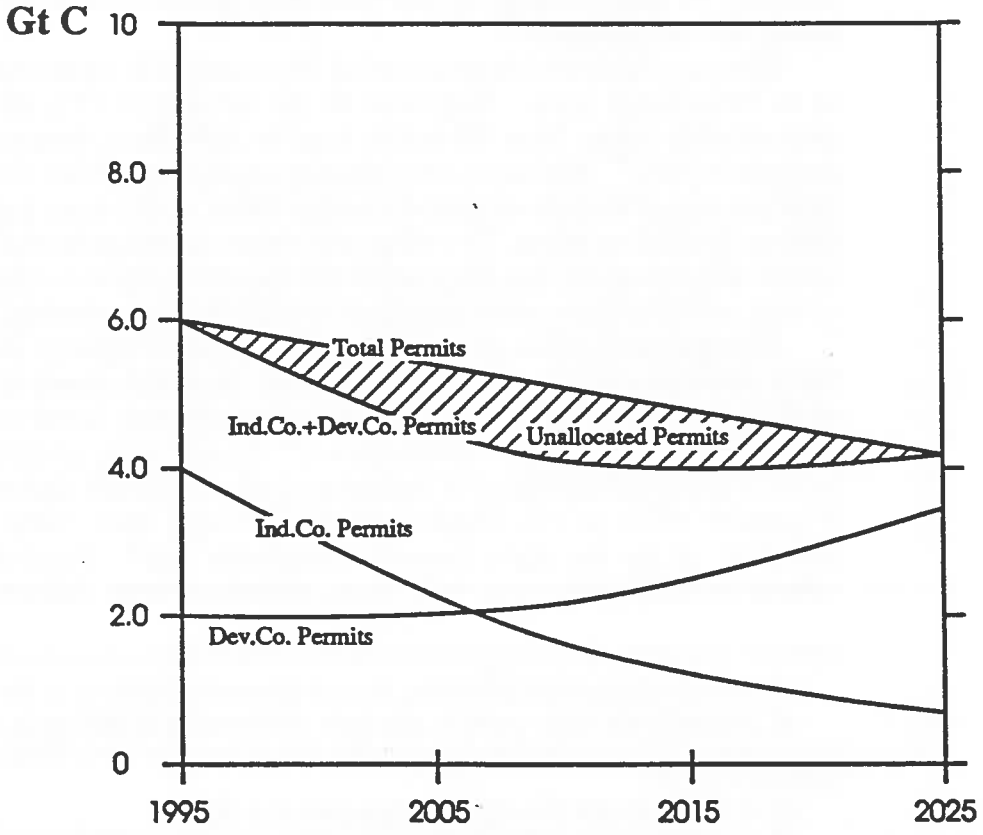
43. Some commentators have suggested basing allocations on current population levels. *See* Anil Markandya, *Global Warming: The Economics of Tradeable Permits, in* BLUEPRINT 2: GREENING THE WORLD ECONOMY, *supra* note 8, at 52, 59; MICHAEL GRUBB, THE GREENHOUSE EFFECT: NEGOTIATING TARGETS 37 (1989); AGARWAL & NARAIN, *supra* note 35, at 20. Since developing country populations are certain to grow, a common per capita emissions target should reflect estimated growth without rewarding countries for exceeding estimates or penalizing them for falling short.

44. This table and those that follow are based on data from WRI 92-93, *supra* note 7, at 246-47, 346-47. The percent annual adjustment (R) is given by the formula $R = \ln((.5/E_{pc})(P_{2025}/P_{1995}))/30$; where E_{pc} is per capita emissions and P is population.

period prior to 2025 when emissions converge at a common per capita level. This is illustrated in Figure 1. The creation of unallocated permits will reach a peak between the years 2005 and 2015, when such permits will be most needed for the acquisition of abatement technology by developing countries. After 2015 the aggregate value of unallocated permits will decrease, until they cease to be created in 2025. By this time, it is expected that major investments will have been made in abatement technology, and developing countries will have sufficient resources, including their own supply of unused permits, to continue on the path of energy-efficient and sustainable development.

Figure 1
Energy-related Permit Allocation



2. Damage Fund

An annual damage fee would be levied on each country, based on its contribution to global warming and on actual damage costs for the past year. Making the annual damage fee proportional to each country's per capita contribution to GHG increases would be a crude but manageable formula for

sliding-scale fees. For example, suppose the fee is set at $0.25 per ton of carbon equivalent emissions per capita. The United States, which each year adds approximately four tons of GHGs to the atmosphere (in carbon equivalent terms) per capita,[45] or one billion tons total, would pay 4 x $0.25 x 1 billion = $1 billion annually. As it becomes possible to determine with more certainty the relationship between a country's per capita emissions and its contribution to global warming, more sophisticated formulas for determining damage fees can be developed.

D. Deforestation

Emissions trading alone may not provide adequate incentives for sufficient reduction in the rate of global deforestation. Thus, countries should commit to phasing out deforestation according to a negotiated schedule. A straight-line phaseout of deforestation by the year 2025 would reduce carbon emissions about .057 Gt per year.[46]

Permits could provide an incentive for countries to phase out deforestation at an even faster pace. Estimates of the amount of CO_2 released through deforestation range from 80 metric tons to 165 metric tons per hectare and perhaps higher.[47] Assuming that permits trade somewhere between $10 and $100 per ton, a hectare of closed tropical forest would have a permit value of $800 to $16,500 or more. To realize this value, countries would be required to forego deforestation, but they could still benefit from non-emitting uses such as fruit and latex harvesting, sustainable-yield timber harvesting, or ecotourism.

The economic value of not deforesting would be equal to the area's permit value plus any additional non-emitting uses. If permits trade at the upper end of the range, the economic value of a hectare of intact forest may well exceed the potential return from deforestation.[48] In this case, permits alone would provide sufficient incentive to reduce and even eliminate deforestation. Even if permits trade at the lower end of the range, their value could still be sufficient to tip the scale towards sustainable use.[49] Furthermore, permits should be issued to cover only those emissions from deforestation allowed

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45. WORLD RESOURCES INSTITUTE, WORLD RESOURCES 1990–91 at 348 (1990).

46. Assuming the same emission rate from deforestation in 1995 as in 1990 (1.7 Gt), the annual global deforestation permit allocation (A) is given by A=(1.7/30)(n), where n is the number of years.

47. IPCC RESPONSE STRATEGIES, *supra* note 5, at 98.

48. One study values cattle ranching in Brazilian Amazonia at $2960 per hectare and clear-cut timber harvesting in Peru at $1001. Charles M. Peters et al., *Valuation of an Amazonian Rainforest*, NATURE, June 29, 1989, at 655, 655–56. Another study estimates profits from logging in the Philippines, which contains some of the world's most valuable timber resources, at about $4500 per hectare. *See* Barbier, *supra* note 13, at 159.

49. Because there are many causes of deforestation, many difficult issues would need to be resolved. For example, who would hold the permits, the state or private landowners? Who should receive the proceeds of their sale? What would be done to compensate displaced squatters who engage in "slash and burn" subsistence agriculture?

under the country commitment schedule and phased out according to that schedule, reducing the allocation of deforestation permits each year by .057 Gt.

A summary of the combined strategy is presented in Table 2. The total number of permits created each year is given in column 2. Columns 3, 4 and 5 show the number of permits allocated to countries. Column 3 shows the number of emissions permits allocated to industrial countries, while column 4 indicates the developing country allocations. Column 5 shows the number of permits allocated for deforestation. Columns 3, 4 and 5 are subtracted from column 2 to determine the number of unallocated permits available for the abatement fund, given in column 6. An estimate of the value of these unallocated permits is given in column 7. In estimating the value, it is assumed that the price of permits will increase by $3.33 a year to $100 per ton of carbon in 2025.[50]

Table 2

Year	Total Permits	Indust. Country Permits	Devel. Country Permits	Defores-tation Permits	Unall. Permits	(US$B)
1995	7.7 Gt	4.0 Gt	2.0 Gt	1.7 Gt	0.0 Gt	0.0
2000	7.1 Gt	3.0 Gt	2.2 Gt	1.4 Gt	0.5 Gt	8.3
2005	6.5 Gt	2.3 Gt	2.4 Gt	1.1 Gt	0.5 Gt	16.7
2010	6.0 Gt	1.7 Gt	2.7 Gt	0.9 Gt	0.7 Gt	35.0
2015	5.4 Gt	1.3 Gt	2.9 Gt	0.6 Gt	0.6 Gt	40.0
2020	4.8 Gt	1.0 Gt	3.2 Gt	0.3 Gt	0.3 Gt	25.0
2025	4.2 Gt	0.7 Gt	3.5 Gt	0.0 Gt	0.0 Gt	0.0
col. 1	col. 2	col. 3	col. 4	col. 5	col. 6	col. 7

E. Actual Emissions

To evaluate the proposed emissions permit allocation scheme, it would be helpful to identify realistic expectations for countries in terms of reducing, or, in the case of developing countries, limiting the increase of actual emissions. The studies attempting to estimate these rates differ by orders of magnitude in their conclusions, making it difficult to predict possible reduction rates. For industrial country CO_2 emissions, a rate of decrease of 2.3% per year is

50. For a summary of studies of the level of emissions fees that would be needed to reduce emissions, see Peter Hoeller et al., *Macroeconomic Implications of Reducing Greenhouse Gas Emissions: A Survey of Empirical Studies*, OECD ECON. STUD., Spring 1991, at 45, 46–76.

consistent with a number of these studies.[51] This would yield a reduction from 1995 levels of twenty percent in 2005 and a fifty percent reduction by 2025. Table 3 compares the industrial countries' permit allocations, given in column 3, to their expected emissions, based on an annual rate of decrease of 2.3%, given in column 2. Column 4 shows the number of permits industrial countries will need to purchase if they reduce their emissions at this rate. Assuming permits rise steadily to $100 per ton of carbon by 2025, the cost of the additional permits that would be required by industrial countries is given in column 5.

Table 3

Year	Industrial Country CO_2	Industrial Country Permit Allocation	Cost Deficit	(US$B)
1995	4.0 Gt	4.0 Gt	0.0 Gt	0.0
2000	3.6 Gt	3.0 Gt	0.3 Gt	5.0
2005	3.2 Gt	2.3 Gt	0.5 Gt	16.7
2010	2.8 Gt	1.7 Gt	1.1 Gt	55.5
2015	2.5 Gt	1.3 Gt	1.2 Gt	80.0
2020	2.2 Gt	1.0 Gt	1.2 Gt	100.0
2025	2.0 Gt	0.7 Gt	1.3 Gt	130.0
col. 1	col. 2	col. 3	col. 4	col. 5

For the developing countries, a fifty percent growth in CO_2 emissions is assumed by 2025.[52] This is equivalent to a 1.4% annual increase. Table 4 compares developing countries' permit allocations, set out in column 3, to their expected emissions, shown in column 2. Column 4 shows the number of

51. *See, e.g.*, OFFICE OF TECHNOLOGY ASSESSMENT, CHANGING BY DEGREES 9-10 (1991) (U.S. emissions could be reduced 29-35% within 25 years at minimal costs; ALLIANCE TO SAVE ENERGY ET AL., AMERICA'S ENERGY CHOICES: INVESTING IN A STRONG ECONOMY AND A CLEAN ENVIRONMENT 47 (1991) (U.S. CO_2 emissions can be reduced 71% from 1988 levels at a savings of $2.3 trillion); NATIONAL ACADEMY OF SCIENCES, POLICY IMPLICATIONS OF GREENHOUSE WARMING 73 (1991) (U.S. could reduce or offset its GHG emissions by 10-40% of 1990 levels at low cost or at some net savings).

52. Though some studies project a greater than 50% increase in developing country CO_2 emissions,(*see* IPCC RESPONSE STRATEGIES, *supra* note 5, at xxxiii), a 50% increase is assumed here based on the finding that developing countries can greatly reduce CO_2 emissions through energy efficiency and fuel switching (i.e., from coal to oil, or oil to natural gas) while still obtaining a lifestyle comparable to Western Europe. JOSE GOLDENBERG ET AL., ENERGY FOR A SUSTAINABLE WORLD 210 (1987).

permits developing countries will be able to sell if their actual emissions increase 1.4% per year. Assuming the price of permits rises to $100 a ton by 2025, the proceeds to developing countries from the sale of excess permits are given in column 5.

Table 4

Year	CO_2	Developing Country Allocation	Excess Permits	Value (US$B)
1995	2.0 Gt	2.0 Gt	0.0 Gt	0.0
2000	2.1 Gt	2.2 Gt	0.1 Gt	1.7
2005	2.3 Gt	2.4 Gt	0.1 Gt	3.3
2010	2.4 Gt	2.7 Gt	0.3 Gt	15.0
2015	2.6 Gt	2.9 Gt	0.3 Gt	20.0
2020	2.8 Gt	3.2 Gt	0.4 Gt	33.3
2025	3.0 Gt	3.5 Gt	0.5 Gt	50.0
col. 1	col. 2	col. 3	col. 4	col. 5

To determine whether there will be enough permits to go around, compare the industrial country permit deficit (Table 3, column 4) to the total number of permits. The total number of purchasable permits equals the number of developing country excess permits (Table 4, column 4) plus the number of unallocated permits held by the abatement fund (Table 2, column 6). As can be seen in Table 5, until 2005 and 2010 there are more than enough permits available to meet the needs of both industrial and developing countries. After that time, however, there is a scarcity of permits. Thus, a mechanism for "creating" more permits will be needed.

Table 5

Year	Industrial Country Permit Deficit	Developing Country Excess Permits	Unallocated Permits	Total Excess Permits
1995	0.0 Gt	0.0 Gt	0.0 Gt	0.0 Gt
2000	0.3 Gt	0.1 Gt	0.5 Gt	0.3 Gt
2005	0.5 Gt	0.1 Gt	0.5 Gt	0.1 Gt
2010	1.1 Gt	0.3 Gt	0.7 Gt	-0.1 Gt
2015	1.2 Gt	0.3 Gt	0.6 Gt	-0.3 Gt
2020	1.2 Gt	0.5 Gt	0.3 Gt	-0.4 Gt
2025	1.3 Gt	0.5 Gt	0.0 Gt	-0.8 Gt
col. 1	col. 2	col. 3	col. 4	col. 5

F. Creating Permits Through Afforestation and Reforestation

The potential permit shortfall, as predicted in Table 5, could be made up by "creating" additional permits through afforestation. It is estimated that sixteen million hectares of new forest will sequester about 0.1 Gt of carbon per year.[53] Thus, starting around 2007, it would be necessary to plant about eight million hectares a year to make up the permit shortfall.[54] Although there are other valuable techniques for increasing carbon uptake, such as improved forest and soil management and sustainably-harvested biomass, the difficulty in quantifying the amount of carbon gained would make it difficult to give any credit for the use of such techniques.[55]

Permits created through afforestation should reflect other values as well, in particular, the need to maintain indigenous populations within biodiverse forests. Therefore, monoculture tree farms might get little or no credit for sequestered carbon, and thus should not be used to offset or compensate for deforestation.

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53. Roger A. Sedjo & Allen M. Solomon, *Climate and Forests*, *in* GREENHOUSE WARMING: ABATEMENT AND ADAPTATION 105, 113 (Resources for the Future ed., 1989).

54. A report from the U.S. Department of Energy contemplates the possibility of afforesting 137.6 million hectares in the U.S. alone. Richard A. Bradley et al., U.S. DEP'T OF ENERGY, LIMITING NET GREENHOUSE GAS EMISSIONS IN THE UNITED STATES, EXECUTIVE SUMMARY 17 (1991).

55. Todd Goldman, *Go Carefully on Carbon Sinks*, ECO, Dec. 9, 1991, at 3, 3.

G. Permit Banking

Permits can either expire at the end of the year in which they are allocated or be "banked" for future use. Banking would help smooth out the effects of business and weather cycles and, by ensuring that unused permits do not lose their value, would encourage polluters to defer present-day emissions. This would be environmentally beneficial even if the stockpiled permits are eventually used. While it has been suggested that banking might encourage hoarding,[56] it might also reduce the demand for future permits, making them more available for developing country use.

H. Controlling Small-Scale Emissions

Emissions from fossil fuels used directly by consumers—such as gasoline, natural gas, and heating oil—could be included in the carbon emissions baseline for determining each country's permit allocation. While it is not practical to control such small scale emissions by requiring consumers to obtain emissions permits, vehicle manufacturers and other manufacturers of fuel-consuming products and equipment could be required to obtain permits to cover their products' annual emissions. Permits could be allocated to these manufacturers based on the estimated total emissions of their products in the past year. The permit scheme for these manufacturers would be much the same as the energy-based permit scheme described above: each year they would receive permits covering a slightly smaller percentage of the previous year's emissions. Like other permit holders, manufacturers would have the choices of making their products more fuel efficient, purchasing more permits, or reducing their output.

CONCLUSION

This article proposes a combined strategy for responding to global warming using marketable permits, emissions fees, and country commitments to reduce greenhouse gas emissions and to finance the costs associated with global warming. It recommends that a permit scheme initially allocate permits on the basis of historical emissions but ultimately converge to a common per capita level. This scheme provides a reasonable compromise between the industrial countries' desire to avoid sudden or dramatic disruptions to their economies and the legitimate concerns of the developing countries that the earth's assimilative capacity not be monopolized or used up by industrial countries. It creates an abatement fund from unallocated permits to cover the costs to developing countries of reducing their future emissions and a separate damage fund from sliding-scale emissions fees to cover external costs of GHG pollution, in keeping with the polluter pays principle.

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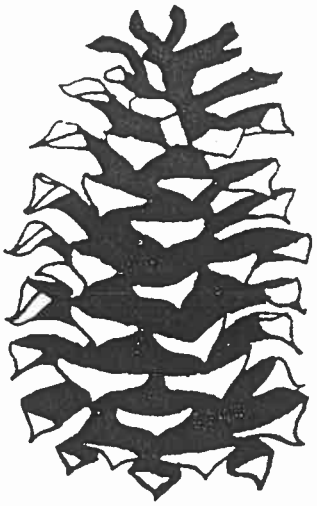
56. Markandya, *supra* note 43, at 60.

This discussion only begins to address the many questions such a strategy raises. A workable system for monitoring CO_2 emissions accurately at national and international levels has yet to be devised. Suitable institutions that could be trusted to allocate permits and identify and deal with violations need to be created. Difficulties with the actual permit trading arrangements, such as the possibility that countries will hoard permits and use monopoly power to eliminate competition, must be addressed as well. Most importantly, any trading scheme's success depends on the participating countries' perception that the system is working.

The difficulties presented by the details of implementing the proposed strategy are beyond the scope of this article. However, if the effects of global warming are as severe as many fear they will be, the international community will have to establish a system of setting emissions limits and sharing the costs of meeting those goals. This proposal is intended to provide an outline of such a strategy. It is the author's hope that the ideas presented here will stimulate further discussion.



Duke Environmental Law & Policy Forum

REDUCING GREENHOUSE GASES: A COMBINED STRATEGY USING FEES, PERMITS, AND COUNTRY COMMITMENTS

DONALD M. GOLDBERG

Volume III **1993**

Published by the Students and Faculty of:
Duke University School of Law
Duke University School of the Environment
Terry Sanford School of Public Policy, Duke University