OPERATIONAL CRITERIA FOR JOINT IMPLEMENTATION -- A DEVELOPING COUNTRY PERSPECTIVE[1]

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1. Introduction

Words, phrases and sentences in international conventions become the basis for intense debate, research and analysis. Thus, the clause in the Framework Convention on Climate Change (FCCC): " Developed Country Parties ... may implement ... policies and measures [which limit their anthropogenic emissions of greenhouse gases] jointly with other Parties ..... in contributing to the achievement of the objective of the Convention ... " has initiated discussion on the criteria for joint implementation.

The paper by Jones[1] is a major contribution to this discussion. It deals with the benefits of joint implementation, cost-effectiveness, targets, comprehensiveness, crediting, costs, instruments, technology issues, risk, and concludes with a preliminary list of operating criteria. Thus, the paper is a thorough, systematic and comprehensive exploration of the operational criteria for joint implementation.

Instead of attempting either a rebuttal or a rejoinder -- which would be a difficult and thankless job -- this comment considers the issue of joint implementation from the perspective of developing countries. However, these countries vary widely, and in particular, the newly industrializing countries (NICs) differ greatly from the other developing countries. Hence, this comment concentrates on the perspective of these non-NIC developing countries.

2. The Earth's Atmosphere -- the Historical Record

Though developing countries have contributed very little to the present high levels of greenhouse gases in the atmosphere, the current growth rates of their emissions extrapolate to dangerous levels in the atmosphere in the future and threaten the industrialized countries. "... a general consensus exists that, during 1988, almost three-quarters of the CO_2 from fossil-fuel combustion was released in industrialized countries. But when non-industrial sources are included (e.g., burning of forests and other land-use changes) the contribution of industrialized countries was about 56%. ... Analysis of the available data suggests that the historical fossil-fuel related emissions from developing countries represent only about 14% of the global total, as compared to 28% of current fossil-derived CO_2 emissions..."[2] The developing countries with three times more population (1) have been far less responsible for "polluting" the global atmosphere with greenhouse

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[1] This paper will serve as the basis of the discussant's remarks on the paper OPERATIONAL CRITERIA FOR JOINT IMPLEMENTATION of Tom Jones to be presented at the International Conference on the Economics of Climate Change, Paris, June 14-16, 1993, organized by OECD and IEA.

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gases, and (2) are even now polluting less than the industrial countries. But, the contribution of these countries to the concentration of greenhouse gases in the atmosphere is rising!

Thus, in a world stratified into rich and poor countries, the bulk of the degradation of the global atmosphere has originated primarily from the rich industrialized countries but the contribution from the poor developing countries is increasingly rapidly.

3. Environmental Degradation in Dual Societies

Most developing countries consist of dual societies with small elites living in little islands of affluence amidst vast oceans of poverty inhabited by the more populous masses. The elites and the masses differ fundamentally in their consumption patterns and therefore in their impacts on the environment. But, environmental degradation is evident at both ends of the income spectrum[3] -- the rich pollute due to the wasteful over-use of resources and the poor degrade the environment by surviving at its expense. Thus, the global phenomenon of non-uniform and skewed contributions to atmosheric degradation is mirrored within developing countries.

Further, attention is now being drawn[4] to the fact that the nature of the environmental degradation caused by the elite and the masses is also different. For example, the rich are responsible for pollution due to CO_2 from automobiles and electricity generation, CFCs from refrigerators, etc. In contrast, the poor are responsible for deforestation in those countries and regions where cooking fuel is obtained by felling trees and where forests are cleared for agriculture because land ownership is highly skewed.

4. A Step-by-Step Environmental Approach for Developing Countries

The relative lack of responsibility of the developing countries for the degradation of the global atmosphere and the environmental degradation arising from elitist growth patterns suggests a step-by-step environmental approach for developing countries[5]:

Step 1: Address local environmental problems such as urban vehicular pollution due to two-, three- and four-wheeler personal transportation, or indoor particulate pollution due to smoke from fuelwood stoves.

Step 2: Tackle regional environmental problems such as acid rain or river pollution.

Step 3: Attend to national environmental problems

Step 4: Pay heed to global environmental problems such as GHG accumulation in the atmosphere.

Such a step-by-step approach will be more politically saleable within developing countries because zeroing in on global environmental problems at the beginning o environmental programs is often viewed as a strategm of the industrialized countries -- a strategm to get the developing countries to fix a mess that the industrialized countries created. In addition, the equity pay-offs from this approach are substantial because the worst sufferers of environmental degradation become the first beneficiaries. And invariably, the worst victims of environmental development are the poor not only because they cannot commute away and space-condition themselves from pollution but because their poorer health status makes themselves more vulnerable. There is also historical justice in this step-by-step approach because it demands that developing countries first address the problems that they themselves created and only then become environmentally altruistic by turning to problems that the industrialized countries created.

5. A Precautionary Approach to the Threat of Global Warming[6]

The most important greenhouse gas directly influenced by human activities is carbon dioxide, with methane being the second most important. More than half of the enhanced greenhouse affect can be attributed to carbon dioxide, with methane being responsible for up to another quarter; hence, the emphasis has to be on these two gases.

Future emissions of GHGs will depend upon a wide range of economic, demographic and policy conditions and are inherently controversial to predict because they reflect different views of the future.

IPCC 1992 estimated a plausible range of annual carbon dioxide emissions in the year 2100 to be 4.6 to 35.8 GtC, compared to 7.4 GtC in 1990, with the central scenarios showing carbon dioxide emissions reaching about 20 GtC -- a three-fold increase over today's emissions. It is, clear, therefore, that if present trends persist, it is very likely that the resulting impacts on the global atmosphere will lead eventually to changes of the global climate that would seriously perturb human societies and perhaps even endanger human life. Further, the response time of the climate system is such that, by the time significant changes are detected, it may take decades to centuries to reverse the damage.

This is why even though there is still much scientific disagreement on the extent and likely consequences of global warming, many countries are committed to putting precautionary policies in place. The idea is that, as further evidence on global warming and its consequences is gathered, the investments of global environmental agencies such as the GEF -- in combination with other sources of private and public sector financing -- will leave the international community better placed to reduce carbon accumulations to safe levels, over the long term, should the need arise. The approach is equivalent to an insurance policy, but it can also be described as "preventive maintenance" in engineering parlance, i.e., taking steps to avoid breakdowns that necessitate major repair and even disaster. The various measures (technologies, practices and policies) that deserve support are those that would need to be turned to on a large scale in a scenario in which carbon accumulations have to be restricted appreciably.

It should be noted that the Framework Convention on Climate Change has a near-term non-binding goal of countries "..... returning individually or jointly to their 1990 levels these anthropogenic emissions of carbon dioxide and other greenhouse gases not controlled by the Montreal Protocol." (Article 4.2b) and a long-term objective of ".....stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system." (Article 2).

A distinction must be made between stabilization of net emissions and stabilization of concentrations. Even with stabilization of global (not just industrialized countries) emissions of GHGs at today's levels, the atmospheric concentrations of most GHGs would increase significantly. For example, carbon dioxide concentrations would increase by about 50% by the end of the next century. IPCC 1990 reported that to stabilize carbon dioxide concentrations at today's level would require an immediate 60 to 80% reduction in global emissions. The larger the reduction of net emissions, the lower is likely to be the level at which atmospheric concentrations stabilize, and the less serious the consequences of these accumulations.

While there is no consensus opinion as to the "safe" level, or the "safe" rate of increase, of GHG accumulations, it is certain that the current uncontrolled rates of increase in global emissions must be significantly reduced, and that even stabilization of global emissions at today's levels may not be adequate. Hence, cost-effective strategies to reduce global emissions must be implemented.

6. Costs of Stabilizing GHG Concentrations[7,8]

Carbon accumulations are rising over time due to the dependence on conventional fossil-fuel energy technologies (Figure 1a). If a safe limit has to be set on the level of accumulations, then it would be necessary to switch eventually to non-fossil alternatives.

Suppose, for heuristic purposes, the switch is assumed to take place at the time T in a step-function fashion (Figure 1b), then the marginal cost of energy consumption would change from the fossil-fuel value of "f" to that of the non-fossil fuel alternatives, "n". Then, the present value c_0 of the extra marginal cost (n-f) at the time $t = 0$ is given[9] by the standard formula which depends upon the discount rate r and time T. Thus, the actual marginal cost of fossil fuel consumption is $f_0 + c_0$ and c_0 is the shadow price or carbon tax necessary to bring about investment in the non-carbon alternatives.

The shadow price increases with time according to the compound interest law[10] but this increase can continue only until it equals the difference (n-f) between the marginal costs of the non-fossil fuel alternatives and the fossil fuels. Thereafter, the non-fossil fuel alternatives become the cheaper and chosen option.

Consider any activity (such as energy efficiency or use of a low-carbon emitting energy resource such as natural gas) that would delay the time at which the carbon accumulations constraint is reached so that the transition to non-fossil fuel alternatives is shifted from T to T+_T. As a result, the present value of the "delayed" marginal cost at the time $t = 0$ is c_0' is less than or equal to c_0 depending upon whether _T) is greater than or equal to zero[11]. Thus, the term c_0' is the shadow price or marginal benefit to be attributed to "buying time" through measures such as energy efficiency, use of a low-carbon emitting energy resource such as natural gas, other emissions reduction measures and sequestration.

The step-function switch to non-fossil fuel alternatives is, however, an over-simplification because (a) the time taken to switch to the non-fossil fuel alternatives in order to comply with the carbon emissions would be quite long and (b) the costs of the renewable energy alternatives are declining while in certain markets (particularly in the non-electric markets) the costs of fossil fuels may rise slowly over the long term. As a result, the programme of introduction of non-fossil fuel alternatives would have to be brought forward to address the marginal increase in CO_2 emissions. In other words, the investments on these alternatives will have to be distributed over time. But how these investments are distributed over the future is a matter of estimating the scope for substituting renewable energy for fossil fuels.

The time profile permits an estimation of the shadow prices to be placed on reducing carbon emissions, but in addition, it is necessary to know the prospective costs of the backstop technologies relative to those of fossil fuel.

7. Costs of Backstop Technologies[12]

A satisfactory portfolio cannot be determined without an analysis of how relative costs are changing. The most promising types of investments in renewable energy are still small scale, and costs are declining with investment and technical progress. The transactions costs of demonstrating and developing new approaches are also initially high. What is relevant therefore is not only (1) their current cost, but (2) the prospects for reductions in costs of the technologies in question, and (3) the contribution that the global environment interventions such as the GEF can make to cost reductions.

The costs of the backstop technologies relative to fossil fuels vary greatly with market and application. They also vary over time. For some applications, renewable energy is already the least-cost option, e.g., the use of biomass for cogeneration, of wind energy in favourable locations, and of photovoltaics for rural electrification and the provision of supplementary power in electricity distribution networks. But substituting renewable energy for fossil fuels on a large scale would likely raise costs. Table 1 presents an illustrative assessment of the long-term costs of using renewables for electric power on a large scale.

In the case of electricity generation, there is growing consensus that the backstop technologies may eventually become competitive with fossil fuels, at least in the high insolation regions of the world. It is for the provision of substitutes for solid, liquid and gaseous fuels (or non-electric energy) that the costs of the backstop technologies are highest. And, non-electric energy currently comprises 60% of the primary energy markets in the industrialized countries and over 65% in the developing countries.

The main backstop technologies are biomass-derived fuels (ethanol and methanol), hydrogen (via electrolysis), or further electrification of the energy markets which will depend crucially on developments with regard to storage technologies. Table 2 summarizes a recent assessment of costs.

That ethanol and methanol from woody-biomass (lignocellulosic) feedstocks could become competitive with gasoline in the long-term (if ex-refinery gasoline prices rise to the level indicated) has been found in a number of industry studies. But, the difficulty with using biomass on a scale sufficient to meet a large share (say 50% or more) of vehicle fuel requirements, is that it is a land-intensive energy source. Bearing in mind the total demand for vehicle fuels (diesel and gasoline) and the growing demands of developing countries in the next 20 years, it is clear that very large land areas would be needed if biomass fuels were substituted for gasoline and diesel fuels on a significant scale. At the same time, the area requirements of agriculture will likely rise appreciably with the growth of population and per capita incomes, depending on technical progress and yields in agriculture.

Thus, however promising biomass fuels may be in terms of cost, they would need, at high levels of substitution, to be complemented by solar-derived hydrogen as a vehicle fuel, or by the electrification of vehicles, again with solar electricity being the primary energy source. The advantage of these options are their relatively low land intensity -- the annual yields of solar schemes are 50-100% greater than those of biomass.

It is, however, not sufficient to look at the cost of the fuel only; the whole system consisting of the fuel plus vehicle must be considered. If hydrogen (produced, say, from PV-generated electricity) or biomass fuels were to become the premier vehicle fuel in the low-carbon-emissions scenarios, it would be through fuel-cell electric vehicles. Technoeconomic studies suggest that

- once they are established in the market, the capital and maintenance costs of electric vehicles based on fuel cells would be comparable with those of gasoline vehicles
- the unit fuel costs of fuel-cell electric vehicles would be greater (Table 2)
- the efficiency of electric motors powered by batteries or fuel cells is about three times that of the internal combustion engine; it is potentially around 60% as compared with 20% in the latter
- electric vehicles have environmental advantages because there are no emissions of harmful gases (assuming the electricity supplies are eventually based on renewables)

These factors suggest that the net costs of turning to hydrogen may be much lower than indicated by Table 2; instead, they are likely to be as shown in Table 3 below.

It seems, therefore, that (a) biomass-derived liquid fuels would be the main backstop technology for some time and (b) that whatever backstop technology is used eventually, and even allowing for the efficiency factor just mentioned, its costs would likely be higher than those of fossil fuels.

It can be argued that since the shadow price, c_t, to be attached to carbon emissions is greater for the marginal backstop technologies than for the most promising non-marginal options[13], the higher shadow prices should be used. Thus, the shadow prices should best based on the costs in the non-electric markets (Tables 2 and 3) where the substitutes for fossil fuels are likely to be more expensive than in the electricity markets (Table 1) where the renewable energy options have good prospects of becoming competitive with fossil (and nuclear) fuels in the long-term.

The logic underlying this view is that the more promising of the backstop technologies whose costs would be less than $f_0 + c_{0,m}$ would then be given added weight when the present value of the costs are compared. At the same time, some marginal technologies with costs close to $f_0 + c_{0,m}$ would not be excluded; only the outliers would be left out, pending further developments. Further, those applications of the backstop technologies that can be identified as having costs lower than f_0 in the so-called "niche" markets, would have the highest returns.

8. A Quantitative Basis for Cost-Effectiveness[14]

Until more reliable estimates of costs are available, a reasonable basis for cost-effectiveness studies might be to take a rounded value of c_0 = $25 per tonne C rising at 10% per year up to a limit of $120 per tonne C. Alternatively, if all comparisons of costs are made in present value terms at t = 0, a constant undiscounted figure of $25 per tonne C might be used. This estimate assumes that by 2010, in a scenario of global warming, a major program of investments in the backstop technologies will be needed.[15]

The figure of $25 per tonne C will clearly need refinement as information changes over time. Significantly, however, it is also in the range of estimates of marginal economic damage from global warming. According to this alternative approach, rates of warming are translated into economic impacts -- such as land inundation from sea level rise -- which are then 'costed' in monetary terms. Recent work suggests that such damage, allowing for some of the uncertainties in estimates, is of the order of $20 per tonne C[16].

The calculations assume a long-term constraint on accumulations. An alternative now being discussed is to limit the rate of growth of global warming to 0.1^0 C per decade. The answer is that the backstop technologies, including the fuel cell electric vehicles, will still be needed in the latter case, so that the same shadow price would obtain. The calculations are, however, more sensitive to changes in the expected costs of the backstop technologies, and also to major changes in perceptions about the severity of the global warming problem. Thus, it can be expected that the estimates -- given the uncertainties involved -- will need to be revised periodically in the light of technical developments and changing evidence on the greenhouse effect.

9. A Two-Pronged Strategy[17]

The investments under the rubric of a joint implementation system should be part of a precautionary policy. Their aim should be to support those activities and investments that would leave the international community better placed to address the global warming problem, should the need arise. Hence, the investments and activities the community supports should be based on the premise that global warming will take place.

In a global warming scenario, the achievement of energy efficiency must be an important element of the policy of reducing CO_2 emissions. But, however economically desirable energy efficiency may be, it will not by itself prevent carbon from accumulating in the atmosphere. Global warming could be delayed by energy efficiency, but it can be prevented only by widespread recourse to the non-net-carbon-emitting or backstop technologies, the most promising of which are renewables.

Hence, the best strategy of addressing the problem of global warming is a two-pronged strategy of

(1) "buying time" with investments that delay the build-up of GHG concentrations up to a particular level and

(2) switching to non-fossil fuel technologies to achieve drastic reductions of GHG emissions, and thereby the level at which the GHG concentrations will eventually stabilize.

Since the first prong of the strategy (viz., energy efficiency, use of a low-carbon emitting energy source, other emissions reduction measures and sequestration) is effective only to a limited, albeit significant, extent, it is essential to back it up with the second prong of non-fossil fuel alternatives which may therefore be called backstop technologies.

The main types of interventions to reduce net emissions of GHGs must be derived from the two-pronged strategy for addressing the problem of global warming: Prong 1: "buying time" through energy efficiency, use of a low-carbon emitting energy source, other ways of emissions reduction and sequestration, Prong 2: non-fossil fuel or backstop technologies.

The two prongs can be elaborated thus:

Prong 1(a) -- Efficiency Improvements: Improvements in transmission and distribution efficiency; Improvements in end-use efficiency.

Prong 1(b) -- Use of Low-carbon emitting Energy Sources: Encouragement of shifts to more environmentally benign energy carriers and transport modes

Prong 1(c) -- Other Emissions Reduction Measures: Reductions of emissions of non-carbon dioxide GHGs; Emissions reduction at the point of End-use

Prong 1(c) -- Sequestration of Greenhouse Gases: Combatting deforestation; GHG sequestration.

Prong 2 -- Non-fossil Alternatives: Reduction of Emissions Intensity of Energy Production through the use of renewable sources of energy (solar and biomass)

10. Least-Cost Net-Emissions-Reduction Planning

The important task with respect to energy-related investments is to develop cost-effective approaches towards addressing the global warming problem. Investments should be directed towards that mix technologies[18] which can achieve the maximum reduction in net emissions for a given investment. The emphasis on net emissions ensures that both abatement and sequestration (and sources and sinks) are considered. The identification of such a mix requires information on the unit cost of emissions reduction for the various interventions and the magnitude of the emissions reduction achievable with these interventions.

If this information were available, one could adopt a least-cost net-emissions-reduction strategy based on cost-net-emissions-reduction-intervention (CNERI) curves (Figure 2). These curves are constructed by choosing the intervention with the lowest unit cost of net emissions reduction and a particular net emissions reduction potential as the first element of the mix, choosing the next most expensive intervention as the second element of the mix, and so on until the desired net emissions reduction target is achieved. Thus, one can estimate the total investment that is required for the mix of interventions to achieve a given magnitude of net emissions reduction. Or, one can identify which mix of interventions is likely to achieve the maximum net emissions reduction for a given total investment.

Least-cost-emissions planning is a worthwhile approach to move towards, for several important reasons:

- it takes into account both the cost-effectiveness of an intervention in reducing net greenhouse gas (GHG) emissions as well the potential impact of that intervention with regard to net emissions-reduction;

- it treats the supply-side and demand-side options for reducing net GHG emissions on equal terms and does not discriminate against either of them;

- similarly, it treats the sources and sinks for GHGs, as well as abatement and sequestration, on equal terms and does not discriminate against either of them;

- it ensures that different interventions are compared and prioritized on the basis of their cost-effectiveness (unit costs and potential net-emissions-reduction);

- it provides some idea of how much reduction in net emissions is achievable (say, in percentage terms) and what cost;

- it constitutes a powerful heuristic for developing an investment strategy and portfolio for reducing net GHG emissions.

Unfortunately, least-cost net-emissions-reduction planning is easier recommended than implemented. This is because of the many conceptual and methodological problems in computing the costs of interventions and in estimating the benefits or effectiveness. In the first place, there has to be an agreed methodology of computing the costs of a net-emissions-reduction intervention, and in particular the incremental costs over and above the conventional intervention. Also, there can be significant reduction of net CO_2 emissions from energy production and use without the carbon accumulations stabilizing at acceptable levels. Thus, the benefits of a intervention cannot be separated from objectives, for instance, whether the objective is mere stabilization of net CO_2 emissions at current levels or stabilization of carbon accumulations at acceptable levels.

11. Full Incremental Costs -- Compared to what?

It is against the background of global and national dual societies that the concept of <u>full incremental costs</u> must be explored. The term "incremental costs" obviously means a difference between two costs, the lower one of which is a baseline cost and the higher one being the cost of an intervention that addresses a global environmental threat such as global warming. Clearly, the baseline cost is a matter that is internal to countries and the higher cost has to be derived from an externally desirable environmental goal agreed to between the countries and the international community.

With regard to the baseline, the first option is to reckon incremental cost compared to what has been the trend of economic growth thus far -- this is the <u>business-as-usual baseline</u>.

The problem with this baseline is that business-as-usual economic growth in developing countries with dual societies has led neither to basic-needs-oriented development nor to environmentally sustainable patterns. Economic growth catering to the elites and neglecting the poor, involving a variety of subsidies, price distortions, inefficiencies, etc., has resulted -- as pointed out -- to environmental degradation from both segments of the dual society. The ruling elites of countries with dual societies would of course like to persist with business-as-usual economic growth but they would adopt environmentally benign technologies in the interests of the global environment if the incremental costs are paid for from external sources. [A cynical Third World environmentalist once described the attitude of developing country governments to the industrialized countries in the following words: "If you don't give us money, we won't do anything for the environment; if you give us money, we will do anything!"].

The recent trend towards liberalization may have aggravate the situation. The market is a superb allocator of capital, resources and manpower, but the market cannot be trusted to take care of equity, the environment, infrastructure and the long-term. What are required are intervention-assisted markets where the interventions are in the interests of equity, the environment, infrastructure and the long-term. Thus, special interventions are necessary to ensure that economic growth leads to economically viable basic-needs-oriented, self-reliant environmentally sound development, i.e., sustainable development.

Both internal and external agents are necessary for these interventions to assist the market. Hitherto, the external agents (including the international and multilateral assistance agencies) have collaborated, and in many cases colluded, with the ruling elites of developing countries in promoting an environmentally unsustainable pattern of growth. But now, the environmental degradation in the form of GHG accumulation is threatening the industrialized countries. So, there is a historic opportunity -- the interests of the industrialized countries and the poor in the developing countries are converging to advance sustainable development. Thus, the central objective has to be a shift from business-as-usual economic growth to sustainable development. Hence, one can also define an incremental cost compared to what could be the costs after the developing country implemented a basic-needs-oriented development goal -- this is a <u>development-focussed baseline</u>.

12. Implications for a Joint Implementation System

12.1. Source of Funds for Sustainable Development

It has been argued in Section 11 that, not only from a national development point of view but even from a global environmental point of view, a shift from business-as-usual economic growth to sustainable development is essential in developing countries with dual societies. But, very often the interventions or measures involved in such a shift also have global environmental benefits. This is the case, for example, when there is a switch from personal petroleum-fuelled vehicles to mass transportation, or from traditional fuelwood stoves to stoves based on biogas or even LPG.

What should be the source of funds in cases where a development-focussed project leads to global environmental benefits as a bonus?

One view is that since the interventions or measures involved in such shift result in net national benefits, the funding of such interventions or measures should be the business of conventional official development assistance (ODA). In other words, the incremental cost is defined on the basis of a development-focussed baseline. And since the intervention or measure is or can be part of the country's development portfolio rather than a global environmental package, the incremental cost is zero. That is, global environment funding facilities should not pay for interventions that ODA should fund.

Another view arises from the fact that, in many cases, ODA does not fund what it should fund. There could be many reasons for this failure to fund, including high transaction costs. In such cases, the interventions must not be allowed to fall between two stools -- global environment funding should pay for the interventions since ODA is not funding them and they result in major global environmental benefits. This is tantamount to lowering the baseline from one with a development-focus to one based on business-as-usual economic growth. In effect, this is consistent with the FCCC which asks for the payment of <u>full</u> incremental costs.

What is being recommended, therefore, is that ODA should fund interventions with net national benefits, but if ODA does not do so, then global environment funding facilities should pick up the bill because of the substantial global environmental benefits. Thus, global environment funding is the default mode. This approach will also set at rest the fear of developing countries that with the current preoccupation with the global environment rather than development, there will be a diversion of ODA funds to global environment funding facilities.

12.2. Shifting Implementation to Developing Countries

Cost-effectiveness is indeed a basic principle guiding the FCCC but there is an issue whether the domain of analysis should be the world or nations. In other words, should the objective function for maximizing be global or national cost-effectiveness?

The trend in joint implementation system discussions is that it is global cost-effectiveness which should be maximized which means that implementation should be concentrated in those countries where interventions are most cost-effective. Apparently, this approach results in the developing countries being the best sites for interventions to capture global environmental benefits. And so many schemes are evolving in which industrialized countries will get credits for financing global-environmental interventions in developing countries.

Does this mean that industrialized countries are let off the hook so that they need not put their environmental house in order? If so, there are issues of equity and credibility. The problem of the global atmosphere is a stock problem in which both historical emissions of GHGs as well as present emission levels (which are a function of present consumption patterns) are relevant. Developing countries have reason to be suspicious of joint implementation systems in which historical responsibilities are ignored, present emission levels in the industrialized countries are left untouched and interventions are promoted in developing countries -- countries that polluted the atmosphere can continue to pollute but countries that contributed little to the pollution of the atmosphere must cease polluting.

This situation can be redressed by computing the cost-effectiveness differently. Suppose, for instance, that in computing the cost-effectiveness, the $ per tonne net carbon avoided ($/tC) of an intervention in a particular country is multiplied by a correction factor (1-h) where h is the fraction of the present anthropogenic atmospheric concentration of GHG for which the country was responsible. Then, if h is greater than 0, (1-h) will be less than unity and the $/tC for the intervention in the country will be less than if the historical emissions factor were ignored. Such a correction factor will not only introduce an element of equity but also compel industrialized countries to set their house in order. Unfortunately, the correction factor is equivalent to the payment of reparations for destruction of the global atmosphere, and it is only the strong who extract reparations.

The emissions situation is analogous to the nuclear proliferation issue where the major nuclear powers were insistent on horizontal non-proliferation while they continued their vertical proliferation. There too the plea was for simultaneous horizontal and vertical non-proliferation.

12.3. Target-invariant Joint Implementation System

A least-cost-emissions reduction curve defines the least-cost mix of interventions necessary to achieve an emissions-reduction target. As long as it is agreed that there should be a non-zero target, an effort can be made to construct a least-cost-emissions reduction curve. Such a curve will identify the cheapest interventions located well below the emissions target. Thus, even there is no precise target, implementation of the cheapest interventions can be initiated as long as the target is above some minimum that is not too close to current emissions, i.e., implementation need not await agreement on the target.

12.4. The Discount Rate Problem[19]

A general principle of environmental policy-making is that policies that address an environmental problem <u>directly</u> are both less costly and more effective than those that address it only indirectly. For example, taxes or regulations on pollution, such as on the sulphur or lead content of vehicle fuels, or to take another example, on the treatment and disposal of spent nuclear fuels, are far more effective in reducing pollution than, say, a general tax or a restriction on energy use. Indirect measures may penalize 'clean' and 'dirty' fuels alike, and have only small effects on pollution while raising costs appreciably; direct measures in contrast may reduce pollution to low levels at a comparatively low cost.

The same principle is applicable to proposals to lower the test discount rate when deciding upon investments intended to address the global warming problem. Such a proposal has been shown to have the following defects: (1) it is a blunt instrument of policy; (2) it may also lead to decisions that contradict the aims of the policy; (3) it favors capital-intensive solutions over labor-intensive ones, and (4) it may sometimes work against investments with more immediate promise (such as renewables) by giving added weight to those with remote prospects (such as nuclear fusion).

In general, therefore, lowering the discount rate is no substitute for direct measures to address a pollution problem, and will not guarantee the required results. While blunt instruments may sometimes serve a useful purpose, the preferred approach is (1) to reflect environmental concerns directly in policy with proper regard for the welfare of all parties, including future generations, and (2) to use a discount rate equal to the opportunity cost of capital.

It is also not very fruitful to allow the discount rate to "suit conditions in recipient countries" because this in effect would lead to raising the discount rate to reflect the capital shortage of poor countries. High discount rates would tend to encourage a short-sighted view biased towards interventions with low first costs rather to promote a long-term view based on low life-cycle costs. Maximizing national cost-effectiveness need not lead to global cost-effectiveness.

The situation is analogous to that involving electricity utilities and their poor consumers. Efficiency improvements (for example, the replacement of cheap, inefficient incandescent bulbs with costly, efficient compact fluorescent lamps) that are desirable from the point of the utilities based on the cost of capital and market rates (of the order of 10%) are rejected by poor consumers whose capital-scarcity leads them to use very high discount rates (of the order of 50-100%). If the high discount rates of the consumers are accepted by the utilities, the efficiency improvements will never be implemented. If the efficiency improvements are to be implemented, the first-cost hurdle has to be overcome by the initial costs being advanced or the efficient equipment/devices being leased or loaned and the capital costs being converted into operating costs. Thus, poor countries behave in decision-making situations like poor consumers who use discount rates far higher than market rates or social discount rates and need the same assistance with the front-end capital.

Table 1: Costs of Electricity Generation, US cents per Kwh (1990 prices)

SOURCE OF POWER	PRESENT	LONG-TERM EXPECTATIONS
Coal	5.0	May rise gradually with fuel prices
Oil	6.0	May rise gradually with fuel prices
Gas (combined cycle)	4.5	May rise gradually with fuel prices
Nuclear	5.5	Rises with environmental factors
Photovoltaics	30-50	7.0
Thermal-Solar	15.0	7.0
Biomass	9.0	4.0-6.0

Sources: Anderson, D. and Williams, R.H., "Cost Effectiveness and the Investments of the GEF", April 1993, Background paper for STAP; also Johansson, T.B., Kelly, H., Reddy, A.K.N. and Williams, R.H., Eds. "Renewable Energy: Sources for Fuels and Electricity", 1992, Island Press, Washington, D.C., Booth, R. and Elliot, P., "Sustainable Biomass Energy", 1990, Shell Staff Technical Paper, Shell Centre, London, Anderson, D. and Bird, C.D., "Carbon Accumulations and Technical Progress -- A Simulation Study of Costs", 1992, Oxford Bulletin of Economics and Statistics, 54(1); 1-29.

Table 2: Costs of Gasoline and Zero Net CO_2-Emitting Alternative Automobile Fuels (US 1990 $ per barrel gasoline equivalent)

	CURRENT	PROSPECTIVE/ LONG-TERM
Gasoline (ex-refinery)	33	45
Ethanol from Biomass	90-103	44-52
Methanol from Biomass	80-89	55-64
Hydrogen from photovoltaic Power	960	144-166

Sources: Same as Table 1

Table 3: Cost Comparisons of Alternative Motor Vehicles

	Break-even gasoline price[a] ($ per gallon)	Undiscounted net life-cycle cost of reducing carbon emissions ($ per ton)
Battery-powered electric vehicle	1.81	354
Fuel-cell electric vehicles		
• Methanol-based	0.72	-175
• H_2-based (biomass)	0.83	-143
• H_2 using PV electricity	1.62	117

Sources: Same as Tables 1 and 2.
a: Break-even gasoline price is that gasoline price (exclusive of taxes) at which the life-cycle cost of a gasoline-powered internal combustion-engine vehicle would equal the life-cycle cost of the alternative vehicle.
b: Assuming a gasoline price of $1.25 per gallon.

End Notes and References

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6... Anon. (1993) "Analytical Framework on Global Warming", Scientific and Technical Advisory Panel (STAP) to the Global Environment Facility (GEF).

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9... The actual expression is $c0 = (n-f)(1+r)-T$

10... The increase of shadow price follows the expression:

$$ct = c0\ (1+r)t$$

11... The present value of the "delayed" marginal cost at the time $t = 0$ is given by

$$c0' = (n-f)(1+r)-(T+\_T)$$

which is related to the "undelayed" extra marginal cost c0 thus:

$$[c0'/c0] = (1+r)-\_T)$$

12... (a) Anon (1993) "Analytical Framework on Global Warming", Scientific and Technical Advisory Panel (STAP) to the Global Environment Facility (GEF).
(b) Anderson, D. and Williams, R.H., "Cost Effectiveness and the Investments of the GEF", April 1993, Background paper for STAP

13... If the shadow prices to be attached to the carbon emissions from the marginal and non-marginal technologies are c0,m and c0,nm, their difference is given by $c0,m-c0,nm = (nm-nnm)(1+r)-T$.

14... (a) Anon (1993) "Analytical Framework on Global Warming", Scientific and Technical Advisory Panel (STAP) to the Global Environment Facility (GEF).
(b) Anderson, D. and Williams, R.H., "Cost Effectiveness and the Investments of the GEF", April 1993, Background paper for STAP

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16... Pearce, D.W. and Fankhauser, S. (1993). "Cost Effectiveness and Cost-Benefit in the Control of Greenhouse Gas Emissions', Keynote Address to IPCC Working Group III, Montreal, May 1993.

17... Anon (1993) "Analytical Framework on Global Warming", Scientific and Technical Advisory Panel (STAP) to the Global Environment Facility (GEF).

18... The word "technologies" has been used here to be synonymous with "projects" in the sense that every project presumes a technology upon which it is based and every technology can be used to design a project around it.

19... Anon (1993) "Analytical Framework on Global Warming", Scientific and Technical Advisory Panel (STAP) to the Global Environment Facility (GEF).

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