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An equity- and sustainability-based policy response to global climate change

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The use of energy for industrial production and consumption over the past 200 years has altered the atmosphere's chemistry. Concentrations of the principal 'greenhouse' gases CO_2 (carbon dioxide), N_2O (nitrous oxide), O_3 (tropospheric ozone), CH_4 (methane) and CFCs (chlorofluorocarbons) – have increased significantly in the atmosphere since the pre-industrial period (Cicerone, 1989; IPCC, 1990; IPCC, 1996a). If we sum across social activities, nearly 60% of the worldwide greenhouse gas emissions (GHGs) are associated with energy production and use (Byrne *et al.*, 1992). In the words of climatologist Nicholas Shackleton, the magnitude of this emission stream and its impact on atmospheric chemistry have taken us "outside what nature has experienced in the recent past 500,000 years" (*New York Times*, January 16, 1990).

Many climate models predict that an atmosphere composed of high concentrations of GHGs will result in higher surface temperatures. Although the precise magnitude and physical dynamics of the greenhouse effect remain the subject of continuing analysis, the UN-organized Intergovernmental Panel on Climate Change (IPCC) has concluded that increasing levels of GHGs are affecting recent climate patterns (IPCC, 1990; IPCC, 1996b, c). The Earth Summit held in Rio in 1992 and subsequent meetings of the Conference of Parties in Berlin (1995), Geneva (1996), and Kyoto (1997) have called for international action to address the problem. The focus of these actions is heavily on the energy sector and the fuels and technologies upon which it relies. The common denominator of most policy proposals is a shift from fossil fuels to an energy system relying increasingly on energy efficiency and renewable energy.

The ensuing policy debate has raised cost and efficiency concerns in reducing GHG emissions and many have counselled a go-slow response (see, e.g., Nordhaus, 1991). Broadly, two precautionary energy policy approaches – 'no regrets' and 'insurance' – have been proposed. Each, in our view, has difficulties that argue against their adoption as an international policy framework. This article proposes a global energy policy alternative that adopts an equity- and sustainability-based approach to the definition and distribution of costs of changing the energy sector to avert climate change.

Two major policy proposals

The debate over policy options to address GHG emissions has so far focused mainly on 'no regrets' and 'insurance' strategies. A 'no regrets' policy (Cristofaro, 1992; Shelling, 1991) responds to global climate change by limiting national actions to those steps that are already cost-effective without the benefits of GHG emission reductions figured in. Basically, the proposal advises countries to accelerate the adoption of relatively low-cost energy efficiency measures such as motor replacement with variable speed drives and relamping with high-efficiency fluorescent lights which are presently justified on benefit-cost grounds. These measures have not been adopted to date mainly due to market barriers, and the no-regrets proposal essentially boils down to a strategy to remove these barriers.

The 'insurance' strategy seeks to purchase some measure of mitigation that will minimize the risk of large-scale catastrophic events from global warming (Cline, 1992; Manne and Richels, 1992). Devoting resources to a modest policy of GHG emission reduction is rationalized under this strategy as a form of insurance against future risks and can, therefore, include measures that go beyond the more restrictive group of 'no regrets' actions. Still, climate insurance strategies largely anticipate emission reductions by means of accelerated diffusion of low-cost energy efficiency measures.

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Analysts espousing either a 'no regrets' or 'insurance' strategy advocate market-style mechanisms as the most efficient way to achieve reductions in GHG emissions (Dower, 1992; Dudek, 1992; Sun, 1990; Bromley, 1990). This is generally contemplated as either the imposition of a global carbon tax or the establishment of an international emissions trading regime.

While the 'no regrets' and 'insurance' policy options can be distinguished in terms of assumptions and arguments, they share several common drawbacks. First, these policies take no account of the international consequences of national decisions. For example, several analysts cite econometric studies by the US Environmental Protection Agency to indicate that building sea walls to protect coastal cities of the US against sea-level rises (should they occur) would cost far less than curtailment of GHG emissions (Passel, 1989; EPA, 1989) and therefore advocate such adaptation responses as an appropriate insurance strategy. But developing nations may find it difficult or impossible to muster the resources necessary to protect themselves from a rise in sea level, especially as some, such as Bangladesh, face the possibility of being almost completely submerged. Yet, these countries would have to bear the burden of decisions by their wealthy counterparts. This represents a distinct type of 'externality' (Baumol and Oates, 1993): an *inequality* externality which is triggered by a condition of unequal wealth.

This points to a second problem. While both 'no regrets' and 'insurance' are represented by advocates as objective strategies to promote an efficient allocation of resources, neither is neutral from a distributional standpoint. Industrial countries possess most of the world's wealth and technical knowledge and, therefore, have a much wider range of options available to them. As a result, these countries can use their market position and control of development assistance funds to influence policy goals, whichever implementation regime (e.g., carbon taxes or tradeable emission permits) is used. Thus, what constitutes a no-regrets action or a reasonable insurance commitment may be determined less by allocative principles than political realities.

A third, shared drawback is that both policy options assume that the atmosphere is, or ought to be, treated as a commodity with its value determined by the contending interests of industrial development and environmental protection. But such thinking is feasible only if we can assume: (1) that the atmosphere has an essentially limitless capacity to absorb GHG emissions; and (2) that societies are equally capable of coping with the natural consequences of global warming. Yet, it is clear that neither of these assumptions is valid. The prospect of global warming itself contradicts the first assumption. However, the economic theory underlying 'no regrets' and 'insurance' approaches lacks an understanding of finite limits of physical systems. see Daly (1991) and Georgescu-Rogen (1981) for an in-depth description of this problem. As a result, there can be no assurance that such strategies will, in fact, realize environmentally sustainable conditions (Byrne *et al*., 1994). Indeed, it is possible for these strategies to produce economically optimal but environmentally unsustainable and even non-survivable outcomes (Pezzy, 1992). As to the second assumption, the existing inequalities of wealth and technological capacity deny its validity. Moreover, it can be readily demonstrated that inequality in economic terms has a direct environmental parallel in the adoption of unsustainable social practices. As Postel has noted:

> [I]nequity is a major cause of environmental decline: it fosters overconsumption at the top of the income ladder and persistent poverty at the bottom.... [P]eople at either end of the income spectrum are far more likely than those in the middle to damage the earth's ecological health—the rich because of their high consumption of energy, raw materials and manufactured goods, and the poor because they must often cut trees, grow crops, or graze cattle in ways harmful to the earth merely to survive from one day to the next (Postel, 1994: 5-6).

An equity- and sustainability-based strategy

The above criticisms underscore two key issues that need to be resolved in a climate change protocol. First, conditions of socioeconomic and environmental inequality must be addressed if full international participation is to be expected. As is well known, continual economic growth in Asia, Latin America and Africa will mean that these regions will account for the bulk of GHG emissions by the second quarter of the 21st century (Flavin and Tunali, 1996). To persuade these regions to be partners in a GHG emission reduction policy, countries will have to be convinced of the fairness of the distribution of burdens. Second, the capacity of the earth's atmosphere to absorb GHG emissions without adverse climate effects must be recognized as placing a ceiling on social activity, especially in the Northern hemisphere where wealth has led to social consumption levels that exceed what is environmentally sustainable (see below). Otherwise, the protocol cannot guarantee that collective action will solve the problem it is designed to address.

We propose a protocol in which sustainability is based on the IPCC's estimates of the reduction in anthropocentric emissions necessary to stabilize GHG concentrations at present levels (see IPCC (1990) (xviii) and IPCC (1996a) 9–11). Equity considerations are then addressed by apportioning across nations on the basis of their 1989 population an annual CO_2 equivalent rate of GHG emissions which is associated with a low warming potential. A detailed description of the analytic procedure used to operationalize the principles of sustainability and equity is provided in the next section. But in general terms, our proposal proceeds from the assumption that no human being and no society is entitled to use the biosphere more intensively than another to pursue its development aims.

A variety of criteria have been proposed to allocate GHG emission rights or quotas. Broadly, there have been five criteria proposed:

(1) the proportionate land area of countries (Westing, 1989);
(2) the proportion of each country's GHG releases to current world emission levels (Benedick, 1991);
(3) the relative size of national populations (Grubb, 1989);
(4) the historical per-capita emission levels (Smith, 1991; Krause, 1989; Solomon and Ahuja, 1991); and
(5) the relative size of per capita GDP (Wirth and Lashof, 1990; Solomon and Ahuja, 1991).

All of these approaches add some measure of fairness. But missing from them is the setting of a sustainable limit to anthropogenic emission rates. In fact, current equity proposals can lead to a significant increase in the amount of carbon in the atmosphere. Several even anticipate a doubling of CO_2 concentrations as inevitable (Solomon and Ahuja, 1991). As argued above, solutions that ignore climate stability requirements to avoid significant warming inherently contain environmental threats that pose disproportionate dangers to developing countries.

Operationalizing the concept of climate stability without significant warming requires that GHG emission allowances are allocated in an equitable manner. Several researchers (e.g., Agarwal and Narain, 1993; Mukherjee, 1992) have attempted this calculation. But considerable disagreement exists on whether and how such a calculation can be performed because of uncertainties concerning the relative effects of various greenhouse gases, their longevity in the atmosphere, non-linear effects of natural absorption processes, etc. (Mukherjee, 1992).

While the complexities involved in this calculation cannot be denied, there are accepted estimates of GHG emission levels sufficient to stabilize atmospheric concentrations (see, e.g., EPA, 1989; World Resources Institute, 1990; IPCC, 1990, 1996b). The IPCC in 1990 estimated the required reduction of GHG emissions needed to stabilize atmospheric concentrations at current levels, and thereby suspend the warming process. These are as follows:

(1) more than a 60% reduction in emissions of CO_2;
(2) 15–20% of CH_4;[2]
(3) 70–80% of N_2O;
(4) 70–75% of CFC-11 and 75–85% of CFC-12; and
(5) 40–50% of HCFC-22.

Based on these reduction figures, a climate-stable GHG emissions level was estimated. The formula used in this estimation relies on the global warming potential (GWP) calculation established by the IPCC in its First Assessment Report (1990) and that organization's estimate of emission reduction rates needed to stabilize atmospheric GHG without triggering significant warming:

$$\left[\sum_i e_i \, GWP_i (1 - r_i)\right] / POP$$

where, e_i stands for the world's emissions of GHG_i in 1989, GWP_i the global warming potential contributed by GHG_i, r_i the required reduction rate to stabilize atmospheric concentrations of GHG_i and POP the total world population in 1989.

In this estimation, the GWP of CO_2 was normalized as 1. The corresponding GWP for CH_4 is 21 and for CFCs, 5873 (World Resources Institute, 1992). The results from the above formula indicate that the climate system (including biospheric absorption and atmospheric storage of GHGs) is currently capable of receiving between 8.5 and 11.3 billion tons of carbon dioxide per year (70% and 60% reduction, respectively),[3] between 4.5 and 4.8 billion tons of CO_2 equivalent of CH_4 annually (20% and 15% reduction, respectively), and between 0.5 and 0.9 billion tons of CO_2 equivalent of CFCs per year (85% and 75% reduction, respectively) without causing significantly greater warming.[4] Adding the emission rates of these gases and dividing that number by world population (about 5.2 billion in 1989) yields what we term *a sustainable GHG emission rate* of approximately 2.6–3.3 tons of CO_2 equivalent of GHGs per person per year. Since N_2O was not included (due to a lack of emission information by country), the sustainable rate used here can be considered conservative.

Our approach does *not* imply a subsidy to populous countries. First, the sustainable GHG emission rate is used to allocate a *fixed* global level of annual emissions to each country based on 1989 population. Under our proposal, this allotment does not change, regardless of population changes, at least through the year 2050. Second, while such an approach means that China and India receive large national allotments, this would be consistent with any approach that recognizes the need to address climate change in the context of the economic needs of these and other developing countries. Finally, all countries under this approach would have incentives to

[2] According to IPCC's Second Assessment Report (1996a) (11), *Climate Change* 1995, annual methane emissions might only need to be reduced by about 8% to remain at current levels. An 8% versus 20% reduction in CH_4 does not measurably change the estimated upper limit of our sustainable GHG emission rate (3.26 vs. 3.34 per person, based on 1989 population). Thus, our analysis is consistent with both the 1990 and 1996 IPCC findings of a climate-stable emission regime.

[3] This includes CO_2 releases due to land use changes.

[4] As noted in the next section, our proposal anticipates a zero emission rate for CFCs. We merely report here what the IPCC has estimated as a climate-stable emissions regime.

control population growth since changes in population have a direct impact on a country's effective emission rates.

On the basis of this calculation, the US is the leader among nations in exceeding its sustainable emission share, with GHG emissions per capita of nearly 26 tons of CO_2 equivalent per year. The world average is a little over 7 tons, meaning that anthropogenic emissions of major GHG gases is currently more than twice the sustainable rate. In contrast, developing countries often release less than 2 tons of CO_2 equivalent of GHGs per person per year. India, e.g., contributes only about 1.8 tons. Current GHG emissions by continent show that North America and Europe (including the former Soviet Union) are major environmental debtors, far exceeding their sustainable GHG emission allotment. The other major debtor at this time is Japan. On the other hand, most countries in Africa, Asia and Latin America emit GHGs below the sustainable rate, constituting environmental creditors. Clearly, industrial countries have appropriated, and continue to appropriate, more than their 'fair share' of the climate-stable emission level. Thus, the first-order burden of reducing GHG emissions must fall to this group, a principle which has been recognized in the Framework Convention on Climate Change.

Operationalizing the proposal

One of the most serious policy challenges now facing the world community is the recognition that global development, energy and environmental problems are systemic in character. If we intend to address the prospect of climate change effectively, we will need to do so in a framework that seeks to end the persistence of poverty suffered by two-thirds of the human community while also observing the requirements of environmental sustainability. To do this, we must fundamentally change the energy, environmental and economic relations that now bind us together unequally. Without change in the pattern of unequal lives and unequal hopes, long-term social equity and environmental sustainability cannot be achieved.

The proposed equity- and sustainability-based policy framework can be used to explore energy, environmental and economic policies needed to meet the goals of climate stability and economic parity. For this purpose, we estimated a regression model which links environment with energy and economy (E^3) on the basis of Kaya's identity (Yamaji *et al.*, 1991):

$$CO_2 = (CO_2/ENG) * (ENG/GDP) * (GDP/POP) * POP,$$

where CO_2 stands for CO_2 emissions in thousand metric tons, ENG the energy consumption in terajoules, GDP the gross domestic product in million US dollars and POP the population in thousands.

The relationships among CO_2, ENG, GDP and POP are estimated for 140 countries[5] using a multiple regression equation in the following manner:

$$\text{Ln}(CO_2) = \beta_0 + \beta_1 \text{Ln}(ENG/GDP) + \beta_2 \text{Ln}(GDP/POP) + \beta_3 \text{Ln}(POP).$$

Data before 1989 are not available for many nations, and the most recent data available are for 1991. A time series analysis was, therefore, infeasible. Instead, data for 1989, 1990 and 1991 were averaged to provide stable figures on which to base a cross-sectional analysis. Each variable in the equation was log-transformed to satisfy the linearity assumption. The coefficients for the multiple linear regression model overall and by income group[6] are shown in Table 1.

The scatterplot of the predicted against actual CO_2 emissions for the overall model (ALL in Table 1) is highly linear and compact. Scatterplots for each of the four groupings of countries by income are similarly compact, suggesting only small estimation errors from use of the linear model. None of the independent variables is highly correlated with another, meaning that multicollinearity poses no problems when interpreting the individual coefficients (all the variance inflationary factors (VIFs) for each independent variable are less than 2). The strong F-values indicate the statistical significance of the model. All of the individual coefficients in the model are statistically significant (as shown in the high t-statistics of individual variables) and have signs as expected. High R^2s and well-behaved residuals indicate that the regressions are adequate to conduct a scenario analysis.

Emissions equality is set as a policy goal for the year 2050, which calls for an annual rate of GHG emissions of 3.3 tons per person per year for all four income country groups. Our target in this scenario analysis is set for only CO_2 emissions because this gas composes more than three-quarters of the GHG emissions, and CFCs, the other main component, are in the process of being phased out in accordance with the Montreal Protocol Agreement. As a means of setting CO_2 emission targets for each income country group to the year 2050, a curve-fitting software package was used to interpolate between the given CO_2 emission values in 1990 and the projected ones for 2050 (see Figure 1).

[5] Several countries are not included in this analysis because data on the four regression variables were not available for the years used in this analysis. Members of the Commonwealth of Independent States and several East European countries are not part of the analysis reported here. Combined these excluded countries account for approximately one-quarter of world GHG emissions.

[6] Study countries are divided into four groups on the basis of World Bank criteria: the low-income group includes countries whose per capita income is less than \$635; the lower-middle income group includes those countries with per capita incomes between \$636 and \$2555; the upper-middle income group has those countries with per capita incomes between \$2556 and \$7911; and the upper income group has those countries with per capita income over \$7912.

Table 1 Relationships among E^3 by income group

Coefficients/ T-statistics	Country Income Group				
	ALL	LO	LM	UM	UP
Constant β_0	− 2.583 (− 24.31)	− 2.794 (− 13.59)	− 2.714 (− 33.63)	− 1.697 (− 3.38)	− 1.212 (− 2.32)
Ln (ENG/GDP) β_1	0.976 (33.39)	0.989 (21.92)	1.052 (30.92)	0.704 (7.29)	0.880 (9.11)
Ln (GDP/POP) β_2	0.974 (70.48)	1.046 (13.34)	0.959 (22.46)	0.967 (4.66)	0.554 (3.86)
Ln (POP) β_3	0.997 (92.15)	1.021 (54.75)	0.997 (89.95)	0.988 (26.52)	0.995 (36.48)
Adjusted R^2	0.992	0.991	0.998	0.979	0.982
F-value	5464.325	1539.009	6913.148	308.673	487.824
Standard error	0.249	0.230	0.121	0.334	0.250
Number of cases	140	44	47	21	28

Note: Figures in parentheses denote t-statistics. ALL denotes all of the study countries; LO is low-income countries; LM is lower middle income countries; UM is upper–middle income countries; and UP is upper income countries.

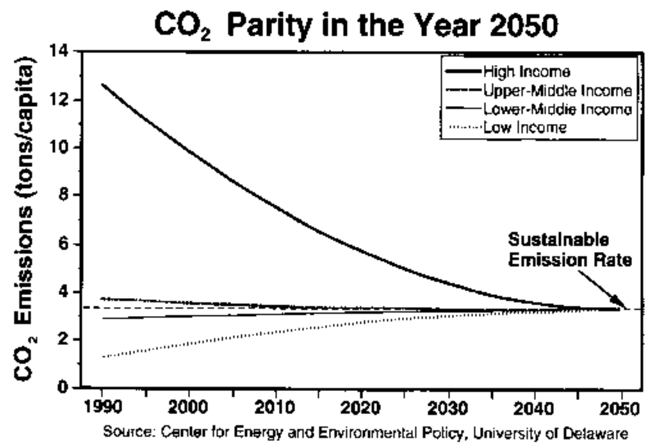

Figure 1 CO_2 parity in the year 2050

In the scenario analysis, we take Kaya's identity and rewrite it so that GDP per capita is calculated from the coefficients of the equation. The scenario analysis treats energy intensity and population growth as exogeneous factors, following a pre-determined path, and GDP per capita is adjusted so that the country groups meet the prescribed CO_2 goal in 2050 of 3.3 tons per capita. Population growth is taken from World Population Office projections,[7] and energy intensity in 2050 is targetted to be at half the 1990 level of the OECD country with the lowest energy consumption per unit of GDP – Switzerland (ENG/GDP = 0.62 in natural log form – see World Resources Institute, 1992). The 1990 levels of energy intensity in natural log-form for low-income, low-middle income, upper-middle income and upper income countries were 3.64, 3.22, 2.77 and 2.32, respectively.

The approach used in the scenario analysis treats GDP as an endogeneous factor, while considering POP and ENG/GDP as exogeneous. We believe that treating population growth as an exogeneous variable is justified on equity grounds. If POP were solved for within the model, the most populous countries – including Brazil, China and India – would be expected to make major reductions in their populations over what is currently forecasted. Yet, these countries contributed little to the accumulation of GHGs in the atmosphere over the last 150 years. Since our approach requires these countries to stabilize GHG emissions by 2050 at an effective per capita rate that declines as population increases further, we are persuaded that this is a reasonable response to the population growth issue *in terms of* climate change policy.

With respect to energy intensity (ENG/GDP), modelling it as an exogeneous factor allows us to set targets that are more agressive than a business-as-usual (BAU) strategy would allow. Since it is essentially impossible to reach climate-stable emission levels under a BAU scenario, an exogeneous treatment seems sensible. In the scenario analyzed here, a goal of reducing the ENG/GDP by 50% by the year 2050 is set for the upper–middle and upper income group countries. This is the rate necessary for these countries to reach the sustainable emission rate by the year 2050. To meet this goal, a substantial portion of future energy services in these countries will need to derive from renewable energy sources (after economical efficiency gains are exhausted). Switzerland currently has the highest renewable energy share of any OECD country in its fuel mix – approximately 50%. Other OECD countries would have to move toward the Switzerland case in order to meet their

[7] Population projections to the year 2025 were taken from the *World Resources* 1994-1995 *Data Base*. Projections beyond the years 2025–2050 were based on extrapolation of the projection to 2025. In our scenario, the average annual population growth rates for developed and developing countries are set at 0.25% and 1.25%, respectively.

sustainability obligations. But they would have over 50 years to achieve such a target, and we are therefore confident of its reasonableness.

In this CO_2 equality scenario, developing countries would experience rapid economic growth, almost achieving economic parity with developed countries. Given the allowance of a CO_2 target of 3.3 tons in 2050, the low-income and lower middle-income countries, which annually emitted an average of 1.2 and 2.9 tons of CO_2, respectively, to the atmosphere in 1990, would register annual economic growth rates of 6.9% and 4.9%, respectively, reaching per capita GDP levels of around $24000 by the year 2050. In contrast, the upper–middle-income and high-income countries would experience slower growth rates (3.1% and 0.5%, respectively), reaching a per capita GDP level of $32000 (Figure 2).

To achieve economic parity and environmental sustainability, a sizable increase in CO_2 emissions in the low-income countries is anticipated to take place, even assuming that energy efficiency and renewables play a major role in the development of these countries (under our scenario, the annual improvement of fossil fuel energy intensities of both low- and lower–middle-income countries is expected to be 2.9% and 2.7%, respectively). For upper-income countries to reduce emissions to the GHG stabilization rate, fossil energy use would have to decrease by about half, to be replaced by energy conservation and the development of renewables (fossil fuel energy intensities of both upper–middle-income and upper-income countries are projected to annually improve by 2.5% and 2.2%, respectively). At the same time, upper-income countries would have to work with low-income countries in acquiring an industrial energy base that increases current system capacity by a factor of four. It should be noted, however, that even while meeting the CO_2 emission targets in Figure 2, the wealthy countries would continue to be massive environmental debtors well into the new century (Table 2).

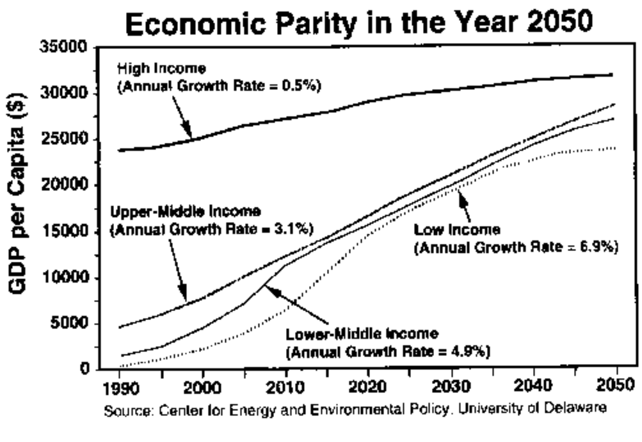

Figure 2 Economic parity in the year 2050

A new global environmental facility

It is widely recognized that the realization of *global* sustainability will depend upon creating access to renewable energy and energy efficiency options and making them economical throughout the world. At the 1992 Earth Summit, it was decided that this need would be addressed through the establishment of a Global Environmental Facility (GEF), jointly operated by the World Bank and the UNDP. However, many countries are dissatisfied with the performance of the GEF.

We propose a change in the financial and political organization of the GEF. Under our proposal, upper–middle- and upper income countries would be required to make contributions (based on a graduated scale) into a GEF for the right to emit CO_2 beyond

Table 2 Projected excess CO_2 emissions by upper-middle and upper-income Countries

Year	CO_2 $/Ton	Excess CO_2 emissions (Million metric tons)		Estimated budget for CO_2 emissions Reduction ($ Billion)
		Upper-income countries	Upper–middle-income countries	
1990	1.00	7,370	153	$7.5
1995	1.25	6,420	130	$8.2
2000	1.50	5,483	110	$8.4
2005	2.00	4,573	91	$9.3
2010	2.50	3,710	72	$9.5
2015	3.25	2,909	54	$9.6
2020	4.25	2,186	40	$9.5
2025	5.00	1,554	28	$7.9
2030	5.00	1,024	17	$5.2
2035	5.00	600	9	$3.0
2040	5.00	287	5	$1.5
2045	5.00	86	1	$0.4
2050	5.00	0	0	$0.0

the sustainable rate. A system of tradeable emission permits could be established through this mechanism, but with important safeguards.[8] Such a system would have to observe the annual emissions caps set in Figure 1. Funds obtained from this source could be utilized to support activities to reduce GHG emissions.

The monetary value of environmental debt payments into such a fund can be determined by an avoided cost method. An avoided cost method assumes that the value of a permit to emit a ton of CO_2 would be equal to the cost of avoiding a ton of such emissions (Byrne *et al.*, 1994). Under this method, the calculation of environmental debt for each country is based on the cost of CO_2 avoidance multiplied by the excess CO_2 emissions of each country over the sustainable rate. Estimates by Flavin (1990) using energy efficiency technologies suggest that the cost to avoid a ton of CO_2 is \$2–\$10 at current prices.

Based on the above method, an estimate of the annual contributions to the GEF by environmental debtors to mitigate global GHG emissions can be made. For this purpose, we chose the conservative lower-end cost limit for avoiding CO_2 emissions of \$5 per ton by 2025. Using the schedule in Table 2, total contributions by environmental debtor countries (i.e., the upper-income and upper-middle-income countries) begin at \$7.5 billion in 1995, increase to \$9.6 billion in 2015 and then gradually decline to zero after 2050.

Until environmental debtor countries have reduced their CO_2 emissions to the sustainable rate, they would be obligated under our proposal to contribute funds according to their level of emissions. Nearly 98% of the total contributions would come from the upper-income countries and the remaining 2% would come from the upper–middle-income countries. As groups, lower-middle-income and low-income countries do not currently contribute excess CO_2 emissions and would not, under the scenario we propose, have obligations to pay into the GEF. This fund could then be used to underwrite emission trades between debtors and creditors while observing the schedule of emission caps in Figure 1.

This approach avoids problems associated with other trading regimes which Agarwal and Narain (1993) have characterized as a form of 'environmental colonialism.' Specifically, wealthy countries would not be permitted to 'bargain' with individual non-OECD countries in order to reduce annual debt obligations. Instead GHG debtors and GHG creditors would interact as blocs via the GEF, thereby allowing creditor countries to set priorities for themselves and then to withdraw funds from the GEF according to those priorities.[9]

The above scenario can be compared to the World Game Institute analysis (1991) which has estimated annual costs for 10 years for the prevention of global warming at \$8 billion annually. This is in the range of the contributions forecast by our method.

Is a solution possible?

The energy, environmental and economic policies needed to meet climate stability and economic parity are substantial. Obviously, these goals will not be easily adopted and met in the context of current world politics. But before concluding that such an approach is impractical, the world community should consider that

- accepting *things-as-they-are* translates into accepting poverty and economic inequality as necessary states for two-thirds of humanity for the foreseeable future; and
- the status quo is purchased at the risk of continuing our experiment in environmental unsustainability. In this vein, the wealthy countries should recognize that they cannot be isolated indefinitely from the consequences of political instability in the developing world that will almost certainly occur without a basic change in international economic, energy and environmental relations.

If wealthy countries support a 'wait and see' policy, they can reap the short-term benefits of economic growth, but the magnitude of future sacrifices required to reach sustainability and equity will be substantial – effectively, such countries would almost certainly have to adopt a policy of real income *decreases* in the long-term. In contrast, if wealthy countries adopt a 'take action now' policy, they may achieve their CO_2 reduction targets with a steady-state economy based on 'low rates of maintenance throughput' (Daly, 1991).

The proposed approach is different from those which aim exclusively for efficiency improvements as a means of averting climate change (see IPCC, 1996d, for a detailed review). An efficiency-minded regime may auger a new era of improved ecological management, but as Byrne and Hoffman (1996) have observed, it maintains a conquest mentality both in social and environmental terms. And, as Herman Daly has warned, it merely perpetuates

[8] Chichilnisky and Heal (1993) argue for the adoption of tradeable emission permits between countries which may lead to the equalization of marginal abatement costs across countries. Due to the nature of public goods, they suggest lump-sum transfers to equate marginal utilities of income across countries before implementing tradeable emission permits.

[9] Of course, the GEF would require a monitoring, evaluation and enforcement mechanism (that should include participants from the debtor and creditor countries, as well as, we believe, independent organizations such as the WMO, UNEP and others). It would also need to evaluate proposals based on explicit criteria before awarding funds.

an oxymoron, the idea of 'sustainable growth' (Daly, 1990) (45):

> The Earth's ecosystem develops (evolves), but does not grow. Its subsystem, the economy, must eventually stop growing, but can continue to develop. The term 'sustainable development' therefore makes sense for the economy, but only if it is understood as 'development without growth'... Currently the term 'sustainable development' is used as a synonym for the oxymoronic 'sustainable growth.' It must be saved from this perdition.

Conclusion

The industrial countries have the wealth, technology and responsibility to solve the problem. But unless they act in partnership with developing countries to avoid globalization of a fossil fuel economy, climate cannot be stabilized, and the persistence of social inequity is threatened. The two groups have a common interest in developing a new E^3 regime as soon as possible (Flavin and Tunali, 1996).

The global community needs to undertake what is uncomfortable but necessary to achieve global equity and sustainability. There really is no other humane choice. For wealthy countries, the global project will require a strong commitment to a social policy at home and an economic policy abroad that aims for a shared ability of human beings to meet the needs of the present without compromising the ability of future generations to meet their needs (WCED, 1987). For developing countries, a significant improvement in lives and livelihoods is needed, but this must be accomplished without repeating the environmental and social legacy of unsustainability of the industrial era. It will not be easy to meet the challenge of equity and sustainability, but it is well worth the effort. If we succeed, we can be at peace with our children, the natural environment and our future.

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