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# The Global Atmospheric Commons: An Entitlement Framework for Management

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# The Global Atmospheric Commons:

# An Entitlement Framework for Management

# DRAFT

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## Introduction

I remember how I first learned about global warming. It was in the late 1980s. My colleague Anil Agarwal and I had spent over two years traversing Indian villages, searching for policies and practices to regenerate wasted common lands. We quickly learned to look beyond trees, at ways to deepen democracy so these commons – in India forests are mostly owned by government agencies, but its poor communities that actually use them – could be regenerated. Equally quickly, it became clear that without community participation, aforestation was not possible. This is simply because our forests are not wilderness areas but habitats of people and their animals. For people to be involved, the rules for engagement had to be respected. To be respected, the rules had to be fair.

In the same period, we had a green environment minister; data released by a prestigious U.S. research institution completely convinced her it was the poor who contributed substantially to global warming – they did 'unsustainable' things like growing rice or keeping animals. Anil and I were pulled into this debate when a flummoxed chief minister of a hill state called us. He had received a government circular that asked him to prevent people from keeping animals. 'How do I do this?' he asked us. 'Do the animals of the poor really disrupt the world's climate system?' We were equally foxed. It seemed absurd. We had been arguing since quite a while that the poor were victims of environmental degradation. Here they were now, complete villains. How?

With this question we embarked on our climate research journey. We began to grasp climate change issues, and quickly learned that there wasn't much difference between managing a local forest and the global climate. Both were common property resources. What was needed, most of all, was a property rights framework that encouraged cooperation. We argued in the following way:

- One, the world needed to differentiate between the emissions of the poor – from subsistence paddy or animals – and that of the rich – from, say, cars. Survival emissions weren't, couldn't be equivalent to luxury emissions.
- Two, managing a global commons meant cooperation between countries. As a stray cow or goat is likely to chew up saplings in the forest, any country could blow up the agreement if it emitted beyond what the atmosphere could take. Cooperation was only possible – and this is where our forests experience came in handy – if benefits were distributed equally.

We then developed the concept of per capita entitlements – each nation's share of the atmosphere – and used the property rights of entitlement to set up rules of engagement that were fair and equitable. We said that countries using less than their share of the atmosphere could trade their unused quota and this would give them the incentive to invest in technologies that would not increase their emissions. But in all this, as we told climate negotiators, think of the local forest and learn that the issue of equity is not a luxury. It is a prerequisite.

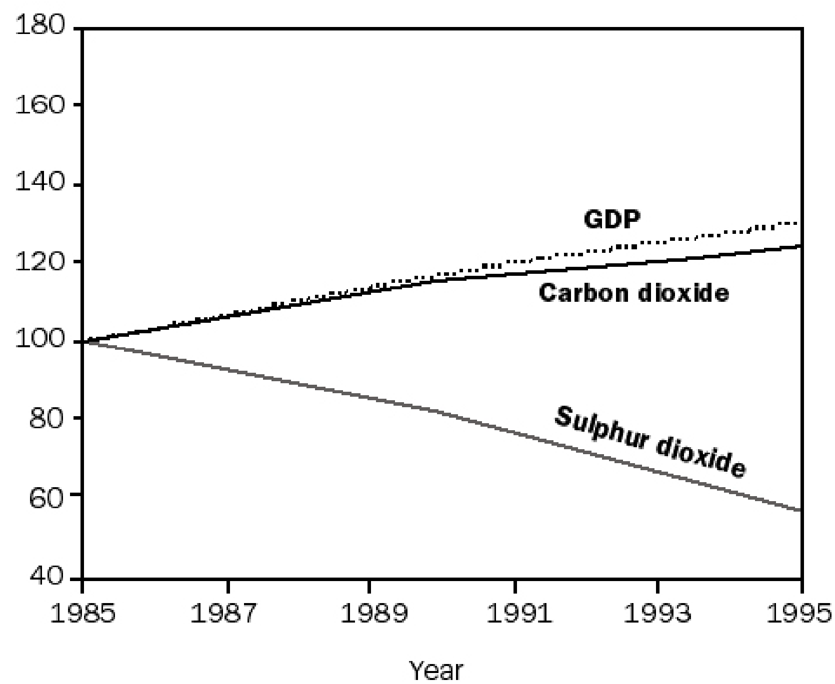
## Climate Change is about the Economy

Industrialized countries have been able to de-link sulphur dioxide emissions from GDP growth, but have failed to do the same with carbon dioxide emissions. Per capita carbon dioxide emissions are closely related to a country's level of economic development and standard of living. It is obvious that as long as the world remains bound to a carbon-based energy economy, it cannot de-link its economy substantially from carbon dioxide emissions. Energy supply was responsible for roughly 80 per cent of global $CO_2$ in 1995.

According to the Synthesis Report of the Intergovernmental Panel on Climate Change, the only time the world 'de-linked' carbon dioxide emissions with economic growth was during the oil crisis of the 1970s, when energy prices rose substantially over a short period of time and lead to a brief divergence of the closely-linked emissions and GDP in the developed world. Otherwise, trends have been predictable. So, the break-up of the former Soviet Union lead to a decline in GDP and with it a sharp drop in its $CO_2$ emissions (IPCC 2001).

Figure 1:

**Growth in GDP versus growth in sulphur dioxide and carbon dioxide emissions in the Netherlands**




The Netherlands has been able to delink its economy from sulphur dioxide emissions but has failed to do the same with carbon dioxide emissions. This is true for all industrialised countries

Source: Anon 1998, National Environmental Policy Plan 3, VROM, The Hague

As long as the world remains within a carbon-based energy economy, equitable sharing of 'atmospheric space' becomes a critical issue, especially for poor developing countries who need the maximum space for their future economic growth. The enormous inequity in carbon dioxide emissions, as it currently stands, is best represented by the comparison between the U.S. per capita emissions and those of South Asian nations, which are amongst the world's poorest nations. In 1996, one U.S. citizen emitted as much as 17 Maldivians, 19 Indians, 30 Pakistanis, 49 Sri Lankans, 107 Bangladeshis, 134 Bhutanese, or 269 Nepalis. Although the gap is narrowing, this extraordinary inequity makes it very difficult for political leaders, especially in nations with an electoral democracy, to agree to a common action plan unless there is a clear recognition of the need for equity in sharing available atmospheric space. Without sharing equitably, global solidarity will not be possible.

But it is equally important to consider the issue of equity within nations. It is clear that the poor of the world are not using their ecological space. Therefore, in any such framework of entitlements, it is the entitlement of the poor, within the poor nations, that needs to be secured.

How will the concept of equity be operationalized in global negotiations? We present a conceptual framework for consideration.

**Ecological and Socially Effective Climate Regimes**

In order to combat global warming, governments of the world must ensure that greenhouse gas (GHG) concentrations do not build up beyond an acceptable level. According to Intergovernmental Panel on Climate Change (IPCC) studies, if $CO_2$ concentrations stabilize at 450 parts per million (ppm) by 2025, global average temperature will increase by 0.4 to 1.1$^{o}$C over 1990 levels, accompanied by a sea level rise of 3-14 cm over 1990. Though this temperature rise exceeds natural variability, it could allow many – though not all – ecosystems to adapt. It can thus be tentatively taken as an upper limit on the tolerable rate of climate change. But even at 450 ppm the estimates of climate sensitivity – uncertainties – could lead to rise in temperatures as much as 4$^{o}$C.

To stabilize at 450 ppm, cumulative $CO_2$ emissions have to be limited to a total of about 600-800 gigatons of carbon (gtC) between now and the end of the 21st century, by which time annual emissions should diminish to less than 3 gtC per year. But under a business as usual scenario, cumulative emissions between now and 2100 will be about twice as high, at 1500 gtC, with annual emissions reaching 20 gtC per year and accelerating upward. The world could expect a warming of 1.4 to 5.8$^{o}$C above 1990 levels and a sea level rise of 9 to 88 cm by 2100 under this scenario. This will adversely affect natural habitats, agricultural systems and human health, and have severe implications for coastal and island ecosystems and their human communities.

The 450 ppm stabilization trajectory, despite being a dramatic deviation from business as usual, is itself not without considerable risks. Not only would it commit the world to a non-trivial degree of climate change, it could subject the global climate system to a radical shock due to non-linear mechanisms that are incompletely accounted for in existing climate models. Evidence from prehistoric climatic records is increasingly supporting the view that the climate system can change rapidly with dramatic ecological impacts. Relatively small human-induced changes could thus be amplified by positive feedback that operates within larger systems that cannot be controlled by human beings (Kartha *et al.* 1998).

By 2000, the current global concentration of carbon dioxide alone (ignoring other GHGs) was around 368 ppm. Nobody has as yet talked about stabilizing atmospheric concentrations at this level in the next century or thereafter. Nor has anyone talked about stabilizing at 750 ppm even though business as usual scenarios show concentrations rising well above 750 ppm. Most of the discussion has been between 450 ppm and 650 ppm (Jacoby *et al.* 1998). The EU has only accepted the 550 ppm carbon dioxide stabilization scenario (Onigkeit and Alcamo 1998).

In terms of per capita emissions, not interfering with the world's climate poses an extremely daunting challenge. It means that both the North and South will have to reduce per capita emissions substantially. The North must reduce its current carbon emissions of 3.2 tons per capita per year from fossil fuel sources to about one-tenth. High-emitting nations like the U.S. would have huge challenges to reduce from 5 tons per capita to 0.5 tons per capita per year within the next 50 years or so. In addition, the South would never be able to reach high emissions and must begin stabilizing and eventually reducing its own current per capita carbon emissions of about 0.5 tons per capita by half even as its population and economies motorise and industrialize in the years to come (Kartha *et al.* 1998).

Climate scientists, Bert Bolin and Haroon Kheshgi estimate that for stabilization at 450 ppm, the global per capita emissions would have to decrease from the present 1.1 ton/capita/year to below 0.5 tons/capita/year by the middle of this century. Stabilization at 550 ppm would require a rapid decrease of emissions by industrialized countries and also by developing countries. In this scenario, developing countries would never emit more than 1.3 tons/carbon/capita/year. Even with the high emissions scenario of 1000 ppm, global per capita emissions would have to be frozen at 1.4 tons per capita/year (Bolin and Kheshgi 2001). Given the carbon-economy linkage, this could imply that developing countries would not be able to grow further and would essentially mean freezing inequities, something that cannot be acceptable in international governance.

According to a 1998 report published by the Stockholm Environment Institute (SEI), 'If the North accepts the risk that dangerous climate change might occur, relying on its ability to adapt to a changing climate, it must still face the geopolitical, demographic, economic and human problems inherent in the South's likely inability to similarly adapt. Alternatively, if the countries of the North decide to avert climate change by forcing an inequitable burden on developing countries, they court similar problems. It is thus compelling that an equitable burden-sharing system be adopted for a timetable of progressive global carbon reductions consistent with climate stabilization (Kartha *et al.* 1998).

Global negotiations have thrown up emissions trading as the most economically effective strategy for emissions reduction, and equal per capita entitlements and convergence as the key components for equity and global solidarity. But there has been very little discussion on what constitutes ecologically effective action.

To deal with global warming, nations not only have to change their current carbon-intensive energy path by undertaking energy efficiency measures, but they ultimately have to move towards a zero-carbon energy-based economy as fast as possible. Though the two are not mutually exclusive, a focus on energy efficiency measures could pose a serious risk to a zero-carbon energy transition. Such a focus could 'lock in' fossil fuels for a much longer time than desired and 'lock out' renewable energy sources (RETs). Many studies show that governments must take a proactive role in promoting the transition here and now. Though a zero-emissions future looks more promising today than ever before, the transition will not take place by itself.

**Trading in Carbon is not Sufficient**

A market-based Clean Development Mechanism (CDM) that seeks least-cost options could actually end up becoming an obstacle for a zero-carbon energy transition, rather than a solution to the global warming problem. The net results of the flexibility mechanisms – providing for trading in emissions – may ultimately be substantially higher emissions reduction costs. This is because any strategy that seeks to obtain least-cost carbon emission reduction options will inevitably focus on improving energy efficiency in the carbon energy sector.

The question then is, will energy efficiency within the fossil fuel energy scenario be sufficient to avert global warming, or will the world need to invest urgently in changing the energy trajectory?

According to a 1996 World Bank study, in an energy-efficient fossil fuel scenario, global carbon emissions will rise from around 6.23 gtC in 1990 to about nearly 22 gtC by 2050. On the other hand, a combination of renewable energy and energy efficiency could return global carbon emissions to just slightly more than 1990 global carbon emissions. Dennis Anderson, a senior adviser in the World Bank's industry and energy department, says, 'it will not be possible to prevent the accumulation of carbon in the atmosphere unless non-carbon (or non-net-carbon-emitting) alternatives become available. Improving energy efficiency will help and is important for economic as well as environmental reasons, but it will not prevent carbon accumulations from growing exponentially or indefinitely, so long as carbon emissions from the burning of fossil fuels exceed 2-3 billion tons per year – the current estimate of the 'natural' net rate of absorption of carbon by the earth's oceans and land masses. Presently, the rate of emissions is around 6 billion tons per year, and emissions are growing almost in direct proportion to world energy demand; it is conceivable that emissions will exceed 10 billion tons in 20 years, and 20 billion tons in 50 years – and this would be in an energy-efficient world.'

Several studies show that a rapid shift towards a zero-carbon energy transition is not only the best but also possibly the only option to combat climate change in the next century itself. If the world waits for a large part of its oil and coal resources to be exhausted before this shift occurs, which will not be before the 22nd century, then the certainty of serious climate change occurring becomes inordinately high, almost definite.

A study conducted by Ujjayant Chakravarty and others at the University of Hawaii has tried to measure the impact of solar energy penetration on future carbon emissions. The study shows that in the baseline scenario, in which global carbon emissions grow for nearly 180 years and reach a peak of 49 gtC in 2175, average global temperatures rise to a maximum of 6$^{o}$C (relative to 1860). But in the most optimistic solar energy penetration scenario, under which the prices of solar energy systems fall by 50 per cent per decade, global carbon emissions will peak at only about 13 gtC in 2035. Global average temperature will rise by 1.5$^{o}$C and begin to decline after 2055, making global warming a problem that can be dealt with within the first half of the next century. Solar energy would have become competitive enough to replace fossil fuels in every economic sector by 2065.

Even a relatively pessimistic scenario in which solar energy costs decline by 30 per cent per decade makes a salutary difference. If this 30 per cent decline is accompanied by a carbon tax on fossil fuels of about US$100 per ton (raising coal prices by about US$70/ton or 300 per cent, and oil prices by about US$8 per barrel), the effects are the same as the earlier scenario, with a 50 per cent decrease in solar energy prices every decade (Chakravarty nd).

On the other hand, moving towards clean coal technology has a limited impact. The model assumes that a new coal combustion technology will become available by 2020, which removes 50 per cent of the carbon dioxide emitted by coal. In this case, peak temperatures rise by about 4$^{o}$C but prior to 2045 clean coal technology does help to control temperatures and delay global warming even more than the most optimistic solar energy penetration scenario of 50 per cent rate of solar cost reduction per decade. But once oil and natural gas run out, the global energy economy will become totally dependent on clean coal and temperatures begin to rise rapidly. In other words, clean coal has good short term, but bad long term, implications (Tse and Chakravarty nd).

A major study conducted by the International Institute for Applied Systems Analysis (ILASA) based in Austria and the World Energy Conference (WEC), entitled *Global Energy Perspectives,* also points to the importance of RETs. With appropriate 'technology push and policy pull', RETs could contribute as much as 37-39 per cent of the global primary energy supply by 2050 and net carbon emissions could be below 1990 emissions by as much as 15 per cent.

The ILASA/WEC study shows that gross global carbon emissions from fossil fuel combustion could rise from 6.23 gtC in 1990 to anywhere between 5.93 gtC to 16.00 gtC in 2050 and per capita carbon emissions from 1.18 tons of carbon (tC) in 1990 to anywhere between 0.59 tC to 1.59 tC. Gross carbon emissions of OECD countries could rise from 3.03 gtC in 1990 to anywhere between 0.79 gtC to 4.42 gtC in 2050. Those of developing countries could rise from 1.85 gtC in 1990 to anywhere between 4.2 gtC to 9.02 gtC in 2050.

Both in the case of OECD and developing countries, gross carbon emissions remain at the lower end of 2050 projections only where governments take a proactive position to push for non-polluting RETs and for energy efficiency. In such a scenario, OECD countries will be able to cut their 1990 carbon emissions by about 75 per cent and developing countries will be able to stay within 2.5 times their 1990 carbon emissions. The world as a whole will be able to return to the gross carbon emissions of 1990. Any deviation from this path would mean that even by 2050, the world will not be able to reduce its gross carbon emissions below the 1990 levels, which are in themselves two to three times higher than those that are considered to be environmentally sustainable.

But the study warns that capital turnover rates (the time it takes to recover investment) of energy supply technologies, and particularly of infrastructures, are five decades or longer. So it is research investments made in the next few decades that will shape the technology options available to the world even after 2020. The more the world gets locked into fossil fuel-based systems, especially efficient and low-cost fossil fuel systems, the longer it will take to get out of them. Already, despite major technological innovations and cost reductions, RETs, are failing to penetrate the U.S. market significantly. RETs not only have to compete with the cost of existing fossil fuel systems but also with the falling costs of increasingly efficient fossil fuel systems in the future.

Therefore, unless the mechanisms of the Kyoto Protocol are carefully designed, they will result in an enormous build-up of greenhouse gases, especially when we take into account that huge energy investments will be made by developing countries in the next 3-4 decades. If these investments lock developing countries into a carbon energy economy like that of the industrialized countries, it will be very difficult for them to get out of it fast. Given the predicted severe impacts of climate change, the world's governments must not miss any viable opportunity to promote RETs.

## Reinventing the Energy System

It is clear that governments of the world have to play a key role in 'reinventing the energy system' in the 21st century, just as they have played a key role in determining the modern energy supply structure ever since the 19th century. As Christopher Flavin and Seth Dunn of the Worldwatch Institute put it,

> *…energy trends have been dictated in part by a complicated dance between industries and governments, with the former seeking economic gain and convenience and the latter focusing on strategic, social and environmental concerns that the market is prone to neglect* (Brown *et al.* 1999a:16).

The 20th century has actually seen a major transition away from renewable sources of energy, towards a fossil fuel-based global economy. Between 1900 and 1997, world energy use grew over 10 times – but even though the actual contribution of RETs increased by nearly 5 times, its share dropped from 42 per cent to only 19 per cent. The challenge for the 21st century is to return once again to a much bigger share for RETs. This will mean a switch from traditional uses of RETs to modern uses of RETs, including biomass energy (Brown *et al.* 1999a:16).

New RETs are also growing fast — in fact, faster than any method of electricity generation (Priddle 1999):

- Between 1990 and 1997, wind power capacity grew by 25.7 per cent every year (Brown *et al.* 1999a:16). The global installed capacity of wind turbines doubled between 1990 and 1995 (Priddle 1999).
- The recent slowing down of the world economy has proved advantageous for wind energy. Favorable market developments, including the recent decline in interest rates due to global economic problems has benefited wind power – because of its higher up-front capital costs compared to fossil fuel systems – to become the fastest-growing energy source in the 1990s (Gray 1999).
- Between 1990 and 1997, photovoltaics (PV) increased by 16.8 per cent per year (Brown *et al.* 1999a:28). Their annual production is doubling every five years (Priddle 1999). Annual U.S. sales of solar energy technologies are already about US$1 billion. The cumulative purchases of PV worldwide by 1997 were estimated at 800 megavolts (MV) (Brown *et al.* 1999a).
- Technological advances are also taking place in the use of hydrogen as a source of energy, which could have a major impact on the transport sector. By 2010, vehicles operating on fuel cells are expected to be on the road (Anon 1999a, 1999b). The cost of fuel cells has been falling dramatically to only a few thousand dollars per kilowatt (kW), though it must fall further to about $50-100 per kW to compete with the internal combustion engine.
- Modern biomass energy offers immense potential. New biomass technologies can help to produce ethanol from agricultural wastes, which can then be used in cars. On August 12, 1999, President Bill Clinton announced a program for biofuels with the goal of tripling U.S. use of bioenergy by 2010 (Clinton 1999, Anon 1999c).
- These technological developments have led energy experts to be reasonably optimistic about the future of RETs. WEC has developed a scenario in which as much as 45 per cent of the world's electricity is produced from RETs by 2020.

Despite these developments, RETs are still unable to penetrate the market without support, partly because of existing policies. The market for renewable energy is expanding rapidly wherever it is supported by government action. The key question is when will RETs become competitive with mainstream sources on their own?

The biggest obstacles in the way of renewable technologies today are low fossil fuel prices and fossil fuel subsidies in many countries; declining public sector research and development, and plummeting private sector research and development as the deregulation of energy markets increasingly focuses attention on short-term returns (Kartha *et al.* 1998). These factors have led to a definite slowing down of the rate of penetration of renewables-based electricity in the 1990s compared to the 1980s, despite major technological advances, and rapid increases in wind power capacity and PV sales in recent years. As fossil fuel prices are not going to change dramatically in the years to come, rapid expansion in the use of zero-carbon technologies will come only with a proactive official policy aimed at increasing research investment, and creating favorable economic conditions so that mass production can bring their costs down further.

Government research and development investment in renewable energy in recent years has been extremely poor and has been falling. In 1995, it was a mere US$878 million in all industrialized countries put together, less than 10 per cent of the total reported government expenditure on energy research and development (Anon 1997) During the 1980s there was a dramatic fall in official support for renewable energy research though there has been a slight increase in the 1990s. Yet opportunities for increasing research and development investment are not small. A carbon tax of US$5 per ton of carbon will increase the price of oil by just US$0.65 per barrel but it will generate US$10-15 billion in the U.S. alone, which could be used to fund research in solar energy.

Secondly, if a new energy system is to be reinvented to control local pollution as well as global warming, governments will have to create favorable economic conditions. Both PV and fuel cells provide excellent examples of what governments can and should do. A large part of the current world demand for PV is based on government programs. As part of Japan's rooftop program, for instance, more than 6,800 systems were installed in 1998. Shipments to Japan increased from 35 MV to 49.2 MV annually, reflecting strong indigenous support for a grid-connected PV system (Brown *et al.* 1999b).

Just as Japan is playing a major role in the current demand for PV, the Iceland government is playing a major role in promoting fuel cells. In 1999, Iceland pledged to become the world's first hydrogen powered economy. The country's capital, Reykjavik, suffers from severe automobile pollution even though the country gets most of its electricity from clean hydroelectric and geothermal sources. Iceland's commitment has immediately attracted Shell, Daimler-Chrysler and Norsk Hydro, a Norwegian energy firm experienced in making hydrogen, which have set up a joint venture with local firms. Daimler intends to introduce fuel-cell buses. The country hopes to replace all cars and the fishing fleet with fuel cell-powered transport.

Earlier, it was the Californian government that forced car manufacturers to take fuel cells seriously. The state has decreed that by 2004, one-tenth of all cars sold in the state must be zero-emission vehicles or else the companies could be barred from the market. As a result, by next year, carmakers and specialist fuel cell companies will have spent some US$1.5 billion on fuel cells (Anon 1999a, 1999b).

Several studies show that RETs have not only reached a stage where they can take off with government support, in the long run they could also lead to much lower energy investments compared to fossil fuels.

Authors of the ILASA/WEC study, *Global Energy Perspectives*, agree that if energy investments are made carefully, then both annual and cumulative energy sector investments will be lowest in the case of RETs and energy efficiency scenarios. The combination of zero-carbon energy sources and highly efficient technologies will be a critical element of adhering to a low-carbon trajectory. Failing to develop advanced energy producing and energy-using technologies would cause the ultimate costs of GHG mitigation to be dramatically higher than otherwise.

Disconcertingly, projections of the high costs of reducing GHG emissions could become a self-fulfilling prophecy if society, daunted by the exaggerated costs of addressing climate change, defers action and fails to adequately stimulate technological innovation and diffusion. But it is equally clear that if technological innovation and diffusion is postponed, processes of technological 'lock-in' and 'lock-out' can occur, preventing the market entry and associated development of nascent technologies that would ultimately be superior to the status quo, but require a period of continued technological innovation, learning-by-doing, expanded consumer awareness, etc. before they can diffuse widely (Kartha *et al.* 1998).

The real importance of the Kyoto targets lies in their potential to motivate the North to determinedly direct resources towards developing and deploying technologies, infrastructure and institutions that will build momentum toward long-term GHG mitigation options and progressively deeper GHG reductions.

## Using Entitlements to Reinvent the Energy Trajectory

With a package of policies and measures developing countries can take a lead in creating a global market for zero-carbon energy technologies because they have two distinct advantages – they have more solar energy than most Western countries; and they provide a huge niche market in several hundreds of thousands of their villages that are not yet touched by the carbon grid. There are more than 2 billion people today who have no access to electricity. It could be argued that providing them with access to RETs constitutes rural development, not 'emissions reduction'. But there is substantial use of fossil fuels by people who are outside the electric grid. In Indian villages, for instance, diesel and electricity used for operating irrigation pumps constitutes a significant proportion of India's diesel and power consumption.

An excellent example of how technological leapfrogging can help both developing countries' national objectives and the global warming problem comes from the transport sector in India. In the U.S., there is one car for every 1.6 people. If India were to have the same ratio, the number of cars in the country would grow from 4 million, to more than 550 million. That is not likely to happen, but it is entirely possible that by 2020, Indians will be riding one hundred million motor scooters that burn gasoline and are far less friendly to the environment than cars. These scooters accounted for 70 per cent of the motor vehicles registered in India in 1995-96, and most Asian cities are packed with similar smog-makers. If investments in highway and traffic infrastructure and pollution control technology lag behind, one can imagine the widespread mayhem and pollution on the roads of the kind already seen in big cities from Bangkok to Delhi. Polluted cities could provide a huge and rapidly growing market for fuel-cell scooters (Agarwal 1997).

Because of the fossil fuel-based historic industrialization of the North, the South today finds itself facing a severely compromised climatic system if it follows the well-trodden path of the North. The South, therefore, has to bear the extra cost of taking a different path and has to 'get it right the first time'.

This raises several critical issues. Production of energy is based on long-lived capital, which once built, commits a society to a lifetime's worth of emissions. A power plant built today will still be emitting 30 years from now, by which time global carbon emissions would have to be reduced by 25 per cent from the business as usual scenario. The South is witnessing rapid economic growth and its major energy investment decisions in the immediate decades ahead will significantly contribute to the majority of global emissions in the subsequent decades. There is very little that can be done to change the fossil fuel-based path for the next 20 years. But if efforts to make RETs begin to compete by 2020 are not made now, then the world will stay committed to a carbon-based energy economy well into the next century.

A slower rate of reduction today will mean either fast rates of reduction later or a high risk of climate change. This would mean passing on a very heavy burden to future generations (Kartha *et al.* 1998).

## The Framework of Entitlements

It is also clear that preventing climate change is not just an economic or an environmental issue. It is above all a moral and ethical issue. And it is going to be the biggest cooperative enterprise that the world has ever seen. It needs the cooperation of all. This can only happen if there is a sense of fairness in the burden sharing arrangements. Coercion could also work. But it would not last for long. Long-term cooperation only comes with a fair deal.

Therefore, the world has to willingly cooperate to reinvent the energy system. This needs a framework to limit and share the greenhouse gas emissions. The concept of equal per capita emissions entitlements was incorporated in the Buenos Aires work plan at the Fourth Session of the United National Framework Convention on Climate Change (UNFCCC) Conference of the Parties at the insistence of the G77 countries and China. A few studies have tried to elaborate this concept. Two basic approaches have been adopted – one includes historical emissions and the other builds a system of entitlements on current and future emissions.

### *Sharing Historical Emissions*

A study prepared for the Dutch government by the International Project for Sustainable Energy Paths (IPSEP) in 1989 argued that the average rate of global warming should be limited, as closely as possible, to 0.1°C per decade and, as an outer limit, to an increase of 2°C by 2100 over the present. This would mean that the maximum allowable concentration of all greenhouse gases should not exceed 430-450 ppm of carbon dioxide equivalent during the next century, provided these levels decline thereafter. In other words, concentration of carbon dioxide itself should not exceed 380 ppm while other greenhouse gases together add up to another 50 ppm of carbon dioxide equivalent. IPSEP's calculations showed that only a total of 300 billion tons of carbon (btC) could be released between 1985 and 2100 or roughly 2.6 btC each year.

IPSEP then asked the question: How should this 300 btC global carbon emissions budget (over the period 1986-2100) be shared? It decided that budget should be shared on the basis of human population over the period 1986-2100 (that is, in terms of person-years). Its calculations showed that if the existing and projected populations of industrialized and developing countries between 1986 and 2100 were taken into account, then developed countries would exhaust their entire carbon quota of 48 btC till 2100 by 1999, that is, if they continue to release carbon dioxide at their 1986 levels. Developing countries, on the other hand, will be able to emit carbon dioxide at their 1986 rate until 2169.

The IPSEP study further pointed out that developed and developing countries have been emitting carbon dioxide at vastly different rates for a long time. If this historical inequity is taken into account, and the permissible global carbon emissions budget of 428 btC from 1950 till 2000 is distributed between industrialized and developing countries, instead of the 300 btC global carbon emissions budget between 1986 and 2100, then developing countries can continue to emit carbon dioxide at their 1986 rate till 2241. But industrialized countries had already exhausted their entire quota by 1986. In other words, they would have to stop all carbon dioxide emissions right away.

It is obvious that sharing the carbon budget, taking historical emissions into account, provides industrialized countries with so little space for change that, in fact, it provides no space for change. Therefore, it is extremely unlikely that industrialized countries will accept any such proposal.

*Sharing the World's Common Sinks Equitably*

Under this approach, the emissions absorbed annually by the global atmospheric sinks, especially global commons like the oceans, could be distributed equally among all the people of the world, providing each person with an equal entitlement.

In order to avoid global warming, the world will have to produce fewer emissions than the world's sinks absorb. According to IPCC, 1990 emissions must come down by over 60 per cent if atmospheric concentrations of GHGs are to be stabilized. The average annual production of carbon dioxide between 1980 and 1989 has been estimated at 7.1 btC. The average annual absorption by all the sinks for these years was 3.8 btC.

There are mainly two types of sinks for carbon dioxide – oceanic and terrestrial. Terrestrial sinks are national property, but oceanic sinks, which absorb on the order of 2 btC per year, belong to humankind and are common global property. Using the 1990 world population of 5.3 billion, this gives a per capita sink availability of 0.38 tC, which can be considered to be each person's entitlement. But this entitlement is so low that while some countries will reach their limits very fast, there are many developing countries that have already crossed the limit. India's carbon dioxide emissions in 1990 from burning of fossil fuels, gas flaring and cement production, for instance, was 0.22 tC. India should then be entitled to increase emissions up to 0.38 tC and, in the meantime, trade unused emissions, or bank them for future use. Developing countries, which were emitting less than this level in 1990 included all the seven countries of South Asia, African countries like Tanzania, Ghana, Kenya and Nigeria, Asian countries like the Philippines and Indonesia, and South American countries like Peru and Brazil. But several countries like Egypt and China had already crossed this level.

Industrialized countries, way above this per capita level, will find it almost impossible to come down as long as they remain within a carbon-based energy economy. Their emissions will keep contributing to the build-up of carbon dioxide levels in the atmosphere.

*Sharing the World's Emission Budget Equitably*

Recognizing that the build up of GHG emissions in the atmosphere is inevitable in the decades ahead, this approach first fixes the future atmospheric concentration limits for different GHGs, which cannot be exceeded by a certain date. These concentrations will have to be fixed at levels that do not threaten to seriously destabilize the global climate. These concentrations and dates then provide humanity with a global emissions budget over a specified time period, to be distributed among all nations in the form of equal per capita entitlements. This approach demands that the targeted atmospheric concentration be subject to periodic scientific reviews, and changed appropriately. Therefore, per capita entitlements based on this approach, too, would be subject to review. If a country does not use its budget during a particular year, it would have the right to trade its unused budget.

IPCC has estimated the total amount of carbon dioxide emissions that can be emitted in a 110-year period from 1991 to 2100 to reach specified atmospheric concentrations. If the world were to aim for a maximum atmospheric concentration of 450 ppm of carbon dioxide by 2100, then the world can emit an average of 5.73 to 5.91 btC every year, which would have provided in 1990 a per capita entitlement of 1.08-1.12 tC. For a 550 ppm, the 1990 per capita entitlement would be 1.49-1.53 tC.

*Sharing the World's Emission Entitlements Equitably*

Under this approach, nations agree on an ad hoc per capita entitlement to which all countries will agree to converge. To begin with, this emission entitlement could be set at anything like 0.5 tC to even 2.5 tC. This entitlement would be subject to periodic reviews, allowing reductions based on the latest scientific information on the seriousness of the threat of global warming.

The approach may appear ad hoc, but there is already a lot of 'pragmatic adhocism' in the climate negotiations. The amount that industrialized countries are going to emit by 2008-2010 as specified in the Kyoto Protocol, for instance, is pegged to their emissions in 1990. The choice of the base year 1990 is as ad hoc as anything can be. But it has been accepted because industrialized countries have to show that they are reducing their emissions relative to some year. As long as they reduce emissions, it does not matter which year is chosen as the baseline. Some countries in economic transition, in fact, have been given the option to choose their own baseline year. The choice of the amount by which each industrialized country is going to reduce its emissions relative to 1990 emissions was also voluntary and ad hoc. Once again, the targets have been chosen simply in the interest of moving ahead.

An ad hoc entitlement amount can similarly be chosen to get the principle of equity and convergence enshrined within UNFCCC, and get North-South cooperation moving through emissions trading.

Equity also demands that the *principle of equitable entitlements* should be accepted along with the *principle of convergence*; in other words, all nations will reach the same level of per capita emissions entitlements – those nations that have higher emissions than their per capita

**Table 1: Comparison of per capita emissions of USA and South Asia**

| Country | Per capita emissions (tC) | | No. of citizens equivalent to one US citizen | |
|---|---|---|---|---|
| | 1990 | 1996 | 1990 | 1996 |
| USA | 5.18 | 5.37 | 1 | 1 |
| Bangladesh | 0.04 | 0.05 | 130 | 107 |
| Bhutan | 0.02 | 0.04 | 259 | 134 |
| India | 0.22 | 0.29 | 24 | 19 |
| Maldives | 0.19 | 0.31 | 27 | 17 |
| Nepal | 0.01 | 0.02 | 518 | 269 |
| Pakistan | 0.16 | 0.18 | 32 | 30 |
| Sri Lanka | 0.06 | 0.11 | 86 | 49 |

Note: tC: ton of carbon
Source: Gregg Marland *et al.* 1999

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entitlements will slowly reduce their emissions to reach their level of entitlement and those that have emissions below their entitlement can reach up to that level.

Equal per capita emissions entitlements could offer the most just, effective and 'meaningful' way of getting developing countries to engage with the climate change problem. These entitlements have the added advantage of providing developing countries with an incentive to keep their emissions growth path as low as possible, so that they have unused emissions to trade for financial gain.

The emission entitlements become the basis for trading. Low-level polluters can trade their unused assigned emissions with high-level polluters. This would provide the right incentive for low-emitters to keep their emissions low – by moving towards zero-carbon energy systems as fast as possible.

But this will only work if emissions trading can be restricted to projects that promote the zero-carbon energy system. If all CDM projects are zero-carbon energy technologies, emissions reduction costs would indeed be higher than the least-cost options that countries like the U.S. are looking for. But this is an upfront cost for a technology whose costs are coming down rapidly, which means that future emissions reduction costs through the RETs route would be lower.

A study carried out by SEI for the World Bank estimates the additional capital cost of switching over from a coal-based power plant to a solar thermal power plant in India to be about US$0.532 million per megawatts (MW) of installed capacity. In other words, a CDM market worth US$25 billion alone can help to set up some 55,500 MW of solar power plants. Data presented in the 1999 Annual Energy Outlook of the U.S. Energy Information Administration shows that the capital cost of a photovoltaic power station over a coal-based power station is about US$1.81 million (in 1997 dollars). US$25 billion will help to set up 16,500 MW of photovoltaic power plants, compared to the current cumulative capacity of less than 1000 MW. This will play a critical role in bringing down the world prices of solar cells.

Once the pro-renewables strategy is accepted, the purpose of per capita emissions entitlements also gets redefined. Its key purpose then is not to create a framework that forces all countries to converge to a sustainable level of emissions but to create a framework for engaging poor nations such that the world can kick-start a movement towards a zero-carbon energy transition. Once the world seriously starts moving towards such a transition, the entitlements framework becomes increasingly redundant.

The biggest advantage of tradable equitable emissions entitlements is that they immediately engage developing countries and provide them with an incentive to keep emissions low. Unlike the Central and Eastern European countries and Russia, which cannot use their assigned amounts built on 1990 emissions because of their economic problems, developing economies are growing at a very rapid rate. Any entitlement they obtain will be used up rapidly.

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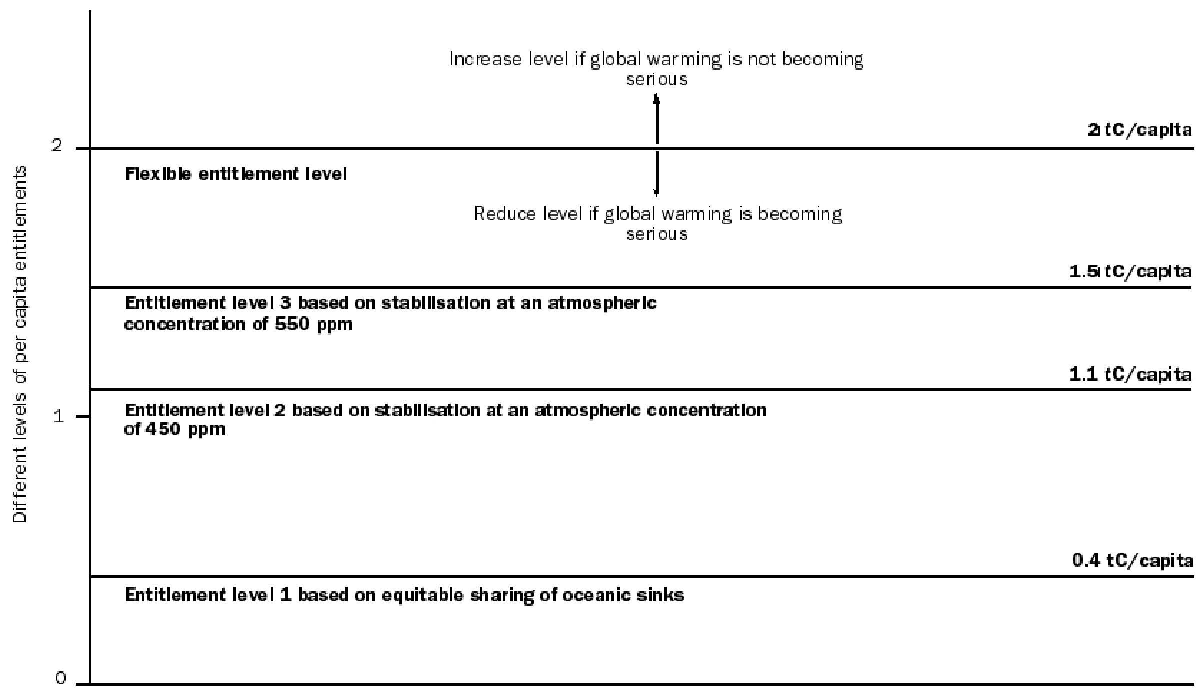
Figure 2:

**Levels of three different approaches to per capita equitable entitlements**




**Investment projections for the energy sector in and by 2050 are the lowest in Case C scenarios, in which use of renewables and energy efficiency are emphasized by governments**

Source: Nebojsa Nakicenovic *et al* (ed) 1998, *Global Energy Perspectives*, Cambridge University Press, Cambridge

However, as it is unlikely that they will use up their entitlements in the immediate future, they have the potential to trade their unused entitlements. This provision would immediately give them an incentive to move towards a low emissions developmental path so that the benefits from emissions trading can stay with them for a long time. The trading system would also provide sufficient financial resources and an 'enabling economic environment for technology transfer' to take place, as indicated in article 10 of the Kyoto Protocol (Agarwal and Narain 1998a, 1998b).[1] It can be argued that any system of per capita entitlement is unjust to those nations that have stable populations, and could provide other countries with a perverse incentive even to increase their populations. With increasing populations, nations will be entitled to emit more and more over the years under a per capita entitlements scheme.

It is rather far-fetched to think that anyone would have more babies simply because they want to increase their emissions quota, but this problem can be dealt with by freezing the global distribution of population with reference to an agreed year, which would ideally be the year of agreement. In this way, no nation can increase its total emission entitlement. If its population grows, then its per capita emissions entitlement will steadily go down.

## Creating National Entitlements

The question then is how could the entitlements be used for zero-emission technologies. One option would be to restrict trade to these technologies. The other would be to create the framework in which it would be profitable to trade only in zero-emission technologies.

It is here that the issue of national entitlements becomes critical. It is both a moral and ethical issue as well as an environmental imperative. The benefits of the resource must be equitably shared for the management of the commons. It is for this reason that countries will need to design an intra-national emissions assignment, as much as an international emissions assignment system.

For instance, India had 16 per cent of the global population and emitted 2.3 per cent of the global GHG emissions in 1990. Per capita emissions were 0.2 tons/capita/year and are expected to increase to 0.5 tons/capita/year in 2020. Per capita consumption of energy is low – 330 kilowatt/hour per year in 1995 (Gupta *et al.* 2001:56).

But these figures hide the huge disparities that exist within India. The urban-industrial sector is energy-intensive and wasteful. While the rural subsistence sector is energy-poor and frugal. Over 80 per cent of the energy used for cooking is biomass-based. The key use of energy in rural areas is electricity used for water pumps and lighting – 35 per cent of rural electricity is estimated to be used for water pumps, which consume 25-40 per cent more energy than efficient pumps. Currently it is estimated that only 31 per cent of rural households use electricity and that frugally. The government aims to connect villages to grid-based electricity, which is expensive and difficult to manage.

It is here that the option of leapfrogging to off-grid solutions like RETs becomes economically viable. It is also the entitlements of the poor off-grid energy users that the rich in the world, including in India, are using for their economic growth. Therefore, the entitlements must be assigned according to per capita energy use. This will provide the incentives for current low energy users to leapfrog to zero-emission technologies, to keep their assignment intact. This rights-based framework will provide the demand for investments in these technologies.

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**Endnotes**

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[1] See also Ujjayant Chakravarty *et al*. nd, and Ujjayant Chakravarty 1997.