GLOBAL ENVIRONMENT AND THE CHANGING NATURE OF STATES

THE ROLE OF ENERGY

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Life on Earth has shown a surprising resilience in withstanding changes in the environmment, and humanity in particular has adapted well to changing climate after the last glaciation some 10,000 years ago when most of the northern hemisphere was covered by ice and snow. However all the natural changes in our environment, except natural disasters, occurred slowly over long periods of time, typically centuries.

The industrial revolution at the end of the 18th century, and particularly in the 20 century, anthropogenic aggression towards the environment has become more important due to population growth and the enormous increase in personal consumption mainly in the industrialized countries. What characterizes these environmental changes caused by mankind is that they take place in a short period of time, typically decades. As result, many new problems or areas of interest in the environmental field have become the object of study and great concern, mainly the ones indicated in Table I.

Table I

Broadly speaking all these problems have a multitude of causes such as population increase, the growth and changing patterns of industry, transportation, agriculture and even tourism. The way energy is produced and used, however, is at the root of many of these causes.

For example, air pollution and acid rain are largely due to the burning of fossil fuels and urban transportation. Greenhouse warming and climate change are due mainly to the burning of fossil fuels. Deforestation and land degradation are due, in part, to the use of fuelwood for cooking.

Such problems are also an important cause of the loss of biodiversity. In some other environmental situations, energy does not play a dominant role but, nevertheless, is important in an indirect way, as in coastal and marine degradation which is due, in part, to oil spills. In the case of environmental hazards and disasters, the role of nuclear energy is paramount as clearly demonstrate by the Chernobyl nuclear accident.

Why are these problems important today and not 100 years ago? The answer to that question in the words of the great russian geochemist, V. I. Vernadsky in 1929 is:

"... Man has become a large-scale geologic force. The chemical face of our planet, the biosphere, is being sharply and consciously changed by man; even greater changes are happening unconsciously".

There are 5.5 billion people on the earth and their average consumption rate of mineral resources in 1994 is about 8 tonnes for a total of 44 billion tonnes. A century ago consumption was less than 2 tons/capita, i.e. 4 times smaller. This is the material actually used. Fossil fuels represents an appreciable part of that. It does not include all of the material moved in order to facilitate mining, the soil disturbed during house building and parking-lot construction, nor any of other disruptions to the crust. It is material dug out and used, directly or indirectly, to feed us, to clothe us, to transport us, to heat us, to cool us and to entertain us. It is material we dig, up, move, process, use and eventually put down somewhere else (Skinner).

We can contrast the annual mineral consumption with the mass of sediment transported to the sea by all rivers of the world. Suspended sediment is stimated to be about 14 billion tonnes per year, the dissolved load is about 2.5 billion tonnes for a total of 16.5 billion tons (Milliman and Meade). <u>This is only 1/3rd of the total mass of mineral resources consumed.</u>

In addition to that, energy sources energy sources (coal, oil, gas, hydro, etc.) are distributed around the globe in a fashion that frequently is not matched to the location of the consumption centers. Access and distribution to most of them creates inumerous problems such as global insecurity of which the volatile political situation of the Middle-East is an example. Other global problems are the ones originating in the use of nuclear energy for electrcity generation which creates the risk of nuclear weapons proliferation.

Conventional wisdom tell us that economic growth is roughly proportional to the growth in consumption of raw materials energy and the resulting pollution. The empirical evidence for such correlation is in general based in studies over limited intervals of time. If such proportionality was to last for many decades the consequences would be disastrous because the economy of a number of very populous developing countries is growing rapidly and GDP/capita would grow and approach the level of the developed countries. This would result in great strains in the access to raw materials and energy, as well as an increase in environmental degradation.

As is well known, in the low income economies of the developing world GDP/capita is at least 10 times smaller than in the OECD (Organization for Economic Cooperation and Development) countries and consumption of raw materials and energy is approximately also 10 times smaller. Presently only one fourth of the world population, in the OECD countries, has reached a standard of living that can be considered acceptable. Of the remaining three fourths - spreadout in more than one hundred countries - only a small fraction of the population has reached a reasonable standard of life, the remaining standing at a level little above absolute poverty.

Figure 1 shows the evolution of per capita income in the period 1930-1988 for the US as well as a number of other countries in 1988 in parity purchase power. It is clear from this figure that some countries (such as Zaire) have a per capita income lower than the US at the begining of last century. Brazil is a stage corresponding to 1950 in the US.

Figure 1

Such disparities in income will not last forever.

The environmental consequences of industrial development and associated energy consumption in developing countries are begining to reach such proportions that they not only threaten the local population but to represent also a sizable contribution to global climate change mainly due to increased fossil fuel consumption.

As an example one can point out that as far as Carbon emissions are concerned the emissions of the industrialized countries have levelled off at a level of aproximatelly 4 Gigatons per year in 1980 while emissions in the developing countries have been growing approximately at 4% per year. If such trends are to continue Carbon emissions from this part of the world will surpass the emissions of industrialized countries around the year 2010.

Figure 2

To attenuate such problems one can introduce more rationality in the use of energy of fossil origin or search for carbon-free sources. This is indeed what happened after the "oil crisis" of the 70's in the industrialized countries. In order to reduce their dependence on oil imports these countries made significant efforts to rationalize their productive systems and suceeded effectively in "decoupling" economic growth from energy consumption. Such efforts were attempted in many other areas with the result that there is a "dematerialization" trend in the world economy in the sense that more was achieved with a reduced consumption of raw materials.

"Dematerialization" is a general characteristic of industrialized countries as they reach higher income. The determinants of such "dematerialization" are

* changes in the structure of final demand
* technological innovations
* efficiency improvements in the use of materials and substitution by alternative materials

Long-term series studies of the intensity-of-use curves (in kg per unit of income) have shown that in general they have a bell shape as shown in Figure 3 for the United States and other countries.

Figure 3

What one learns from those curves is

1. that the intensity of use of a given material (or energy) follows the same pattern for all economies, at first increasing with per capita GDP, reaching a maximum at about the same per capita GDP, and eventually declining;

2. that the maximum intensity of use declines the later in time it is attained by a given economy.

Such behaviour is particularly striking for the "energy intensity" (energy consumption per unit of GDP) of a number of industrialized countries as shown in Figure 4 (only commercial energy was included in this analysis).

Figure 4

What the data shows is that the energy intensity grows during the initial phase of development when the heavy industrial infrastructure is put in place, reaches a peak and then decreases. Latecomers in the development process follow the same pattern as their predecessors, but with less accentuated peaks: they do not have to reach high energy intensities in the initial stages of industrialization, because they benefited from modern methods of manufacturing and more efficient systems of transportation developed by others. This was true even before the oil crisis of 1973, and rising oil prices only accelerated the pace of structural changes in industrialized countries. This process is generally described as technological "leapfrogging"- in which a number of stages or choices made by industrialized countries in the past are skipped by the early adoption of modern technologies in the process of development avoiding the costly retrofits that are required when the investment in obsolete technologies is made.

Enlightened governments can have an enormous success in accelerating this evolution mobilizing local resources, investing in education and developing the indigenous capacity to develop or choose selectively foreign technology. This was to some extent in the case of Japan after the Meijii restoration in the last decades of the 19th century which in 30 years converted Japan into a world power.

What is crucial in this approach is the capacity to choose among technologies and finance preferentially projects incorporating modern technologies or conducting the necessary research for that. The best example of this approach is the one given by Japan after the Second World War with the creation of MITI (Ministry of International Trade and Industry) which is responsible for the support for Research and Development plus industrial development.

There are a number of examples of technological "leapfrogging" (Goldemberg) occurring in the developing countries today such as:

i. The adoption of celular telephones to supplement and sometimes replace completely, obsolete traditional telephone system (which require extensive wiring) in cities such as Manilla or some regions in China. Although celular telephones were originally developed for mobile uses or rural areas where wiring is very expensive, technical developments indicate that they can also be economically competitive for regular service..

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ii. The restructuring of the world steel industry which is in a period of change opening new possibilies for developing countries to enhance their comparative advantages. In the past five years large conventional, centralized and integrated steel mills, which require the use of large blast furnaces, coke ovens and sintering plants have come under attack for their negative environmental impacts, including toxic and carcinogenic by-products. In many parts of Europe, licenses for new plant construction are impossible to obtain. Where plants are in operation, production taxes are often levied - for example, a $ 25-per ton of produced steel "ecotax" is levied on a sintering plant in Oxelosund, Sweden, because of its emissions of dioxin.

One result has been an increase in the use of electric arc furnaces which were used in 35 percent of total steel production worldwide in 1995, compared to 10 percent in the 1960's and 22 percent in 1980. This technology depends on the availabilitty of low-cost electric energy, which is abundant in many developing countries to which modern steel industry is migrating. Another trend has been toward descentralized, small and mid-sized mills (production capacity smaller than one million tons per year). Still another result is the rebirth of charcoal-based pig- iron and steel production in Brazil: 19% of all steel in the country (4.3 million tons) is produced in charcoal-based steel plants in addition to that 4.5 million tons of pig-iron.

When one concentrates attention to energy there a number of opportunities to explore, the main ones bring.

1. The modernization of the use of biomass

*. ethanol production from sugarcane for transportation

* gasefication and electricity generation from biomass

Biomass in the form of fuelwood, agricultural residues, dung and bagasse provides 14% of the world's primary energy (equivalent to 25 million barrels of oil equivalent per day). In developing countries - where it contributes approximately 35% to all energy consumed - biomass is predominantly used as a non-commercial fuel. The modernization of the use of biomass is taking place through the conversion of biomass in liquid and gaseous high quality fuels namely.

2. Photovoltaics

Photovoltaics (PV) technology could play an important role in tropical areas - where most of the developing countries are - not only in decentralized but also in centralized units feeding directly into electricy distribution existing grids. While PV technology is perhaps the most inherently attractive of the renewable technologies it is also - due to its cost - the farthest from being commercial.

Estimates suggest that 2 billion people are without acess to modern electricty, many of whom are willing to pay the full cost for the services it can provide. With suitable delivery systems, one estimates that it may be possible to reach up to 50% of the rural population with PV.

In addition to these wind for electricity production and electric vehicles are significant.

All these new technologies have reached technological maturity - although new improvements are bound to take place - but suffer from the usual problem of initial high cost which is typical of new technologies.

Usually prices of any given manufactured products decline as sales increase according to "experience curves" (or "learning curves") which reflect gains due to technological progress, economies of scale and organizational learning. Experience shows that such decline is exponential as productions grows. An indicator called progress ratio (PR) is in general used to describe it. For example a PR of 80% means that the cost declines 20% for each doubling of production. The lower the PR the faster the decline in cost.

Figure 5 shows the distribution of the PR observed for more than 100 industries indicate a cluster around a PR 80% (Dutton and Thomas). For electricity in the USA 75%.

Figure 5

For photovoltaics costs are falling as indicated in Figure 6 which corresponds to learning curve with a Progress Ratio of of 81,6%.

Figure 6

Aggregation of large international markets for PV sales in developing countries could be a mechanism for accelerating the rate of price reduction for PV systems produced in industrialized countries. Costs could be brought down quickly via mass purchases that could be facilitated by various national and international organizations in conjunction with increased R&D.

What can Governments do to promote the adoption of better technologies and technological "leapfrogging"?

To answer this question one has to realize that such problems fall in three distinct categories and authorities responsible for solving them are different in each case:

* local;
* regional; or
* global

Local pollution has to do with local governments since it deals with clean air, fresh supplies of clean water, the removal and disposal of solid wastes and liquid effluents, street cleaning, etc. This is what has characterized "good" small - and medium-sized cities since Roma times. Yet in many developing countries, a large fraction of the population lives among the rubble and residues that it produces, due to the lack of resources to remove waste and to build sewers and engineering works needed for the supply of water. This is quite evident in the slums of the big cities that, generally speaking, surround "islands of prosperity" where the well-to-do succeed in reaching a quality of life which is comparable to that of Europe or the US. Local pollution goes together with poverty.

Regional pollution is caused mainly by automobiles, energy production and heavy industry which are inherent to more prosperous societies. Large cities and adjoining areas, such as Los Angeles, Mexico City and São Paulo, have been "suffocating"under the pollution caused by the emissions and smog resulting from burning of fossil fuels. Sometimes the amount of pollution produced is large enough to cause regional and even transborder problems, such as the ácid rain'which originates in the US but it is responsible for the destruction of life in canadian lakes. The same happened to lakes in Scandinavia, due to industrial activities on the other side of the Baltic Sea. Regional pollution has to be dealt with at the state or national level and eventually among a number of countries.

The third category is global pollution and its most obvious consequences to date are the destruction of the stratospheric ozone layer by CFCs and the "greenhouse effect". These problems result from changes in the composition of the atmosphere and have little to do with national borders. The causes of such global problems are gases originating anywhere in the world and are such that, for example, the well-being of people living in a Switzerland might ultimatelty be affected by what takes place in India or China (and vice versa). Global pollution can only be tackled at the international level.

When dealing with individual countries Governments can introduce incentives to stimulate better practices and guide markets; one of the most interesting methods for doing it is the one introduced by the United Kingdom which decided that utilities should incorporate a minimum amount of renewable energy capacity into their portfolios, even if utilities have other, less expensives alternative means of providing power.

The United Kingdom adopted the renewables Non-Fossil Fuel Obligation (NFFO) of the 1989 Electricity Act, which privatised the electric power sector. It evolved from the need to find a means of supporting nuclear power, after it was realised that nuclear power could not survive privatisation without subsidy. The British government was required a subsidy permission for the European Commission to levy a tax on electricity in order to subsidise nuclear power. The government asked permission intead for a levy on fossil based electricity to support non-fossil-based electricity, in a Non-Fossil Fuel Obligation (NFFO) - a request that was granted by the Commission. The NFFO came to be understood to include both renewable and nuclear energy (Mitchell).

There are other variations of such mechanisms that are well sumarized in the UNDP publication "Energy After Rio-Prospcts and Challenges" by A.K.N. Reddy, R.H. Williams and T.B. Johansson in 1997.

Another mechanism is the adoption of caps on emissions of pollutants such as was done for SO_2 in the United States; once they are established at a national level the agencies in charge such as EPA - Environmental Protection Agency in the US) can issue emission permits that are tradeable and which encourage technological development of processes that avoid SO_2 emissions.

Dealing with global environmental problem is however the great challenge of our days: it requires international "hard" laws i.e. setting mandatory targets and timetables for the reduction of emmissions of the undesirable gases which will force technological change in the desired direction. In the case of CFCs the Montreal Protocol was succesful in doing that but the same success was not achieved in the case of the other "greenhouse gases" such as Carbon

Dioxide (CO_2), methane (CH_4) and others. The Framework Convention on Climate Change (FFCC) adopted in Rio in 1992 can be clearly cathegorized as an international "soft law" .

Industrialized countries announced in Rio their decision to reduce CO2 emmissions to the level of 1990 goal to be met in the year 2000 but that was not a binding comittment which indeed will not be fulfilled. Actrually emission are growing in most of these countries. On the other hand developing countries accepted no limitations on their future emissions since this could - in their perception - hurt their developement goals.

In successive meetings of the Conference of the Parties (COP) of the FCCC, efforts were made to convert it into a "hard law". The idea is that industrialized countries would stabilize emissions at the level of 1990 and eventually to reduce them by 5-15% by the year 2010. Proposals to have developing countries accepting binding or voluntary targets have also been made mainly by the US. This will require international an agreement on allocations of emission permits which is proving to be quite hard to achieve.

There are however great expectations that in the Kyoto Meeting of the Conference of the Parities in december 1997 some agreement will be reached.

As in the case of SO_2 the acceptance of caps on emissions will stimulate the efforts to findd altenative technologies to produce energy, i.e. carbon - free energy sources which are the renewable ones such as wind, photovoltaics, biomass, hydrogen, etc.. Estimates have been made of the possible role such sources could play early next century. Two of the outstanding projections are the ones made by World Energy Council in an "ecological driven scenario" which predicts that by the year 2020 30% of the total primary energy consumed could renewable as compared to $% in 1990 (Table II)

Table II

There are thus significant opportunities to steer the present day energy system mainly based on the use of fossil fuels to less carbon-dependent primary sources of energy (renewables) as more efficient energy use. Coupled with technological "leapfrogging" one would be moving significantly in the direction of a sustainable future.

Table I
Main Environmental Problems

Environmental Problem	Main Source of Problem	Main Social Group Affected
Urban air pollution	Energy (industry and transportation)	Urban population
Indoor air pollution	Energy (cooking)	Rural poor
Acid rain	Energy (fossil-fuel burning)	All
Ozone depletion	Industry	All
Greenhouse warming and climate change	Energy (fossil-fuel burning)	All
Availability and quality of fresh water	Population increase, agriculture	All
Coastal and marine degradation	Transportation and energy	All
Deforestation and desertification	Population increase, agriculture, energy	Rural poor
Toxic chemicals and hazardous wastes	Industry and nuclear energy	All

Table II
Total Energy Consumption (GTOE)

Year	Scenario	Primary Energy	Renewables
1990		8.8	0.32
2010	OECD/IEA**	11.59	<0.6(<5%)
2020	WEC (ecologicallydriven)	11.3	3.4(30%)
2025	RIGES	11.2	5.0(45%)

* Does not include non-commercial fuels such as wood or animal waste
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