Emergent Diseases

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In an international scientific congress held in Rio de Janeiro, a few years ago, in honour of the hundredth anniversary of the death of Louis Pasteur, Joshua Lerderberg, Nobel Laureate in 1955 for his discovery in bacterial genetics, told the following story about American demography: the population of the United States, from which data are available since the second half of the XIX century, has shown a continuous increase, following a curve without discontinuity, with a recent tendency to decrease its rate. No discontinuity was observed during or following World Wars I and II, or the Korean and Vietnam wars, in spite of the high number of deaths and disabilities that occurred in these periods in the male population at the reproductive age. No discontinuity ... with one exception: a clear drop in the year 1918, as a consequence of the "Spanish influenza" epidemics. Lerderberg called the attention of the audience to the fact that we have not, nowadays, many new tools against virus infections and are not, therefore, more prepared to defend ourselves against this kind of "accident". He concluded stressing the need for developing research on microbial pathology and virulence.

New threats against Human health have indeed been identified in the last decades, with the appearance of new transmissible diseases that, by their epidemic dramatic aspects and mortality effects, provoke crisis of panic in the public and the Health authorities in the World. Among these new pathologies, known as emergent or emerging diseases, the more important is AIDS, produced by a retrovirus, isolated in 1982 as the agent of acquired human immune deficiency, which spread throughout the World in the 80ties but probably was already circulating in Africa for a few decades. Other dramatic examples, that have not assumed, however, the same worldwide extension, were the outbreaks by the African viruses Ebola and Marburg, which produced fulminating haemorrhagic fevers, with violent but limited epidemic outbreaks. This limitation was perhaps due to the extreme virulence of the infectious agents, which induced quick fatal evolution, reducing the transmission efficiency. In another recent example, Europe has been struck (and still is) by the panic concerning the "mad cow" disease, produced by a new infectious agent – the prion – responsible for the bovine spongyform encephalitis that apparently can be transmitted to humans by digestive route. More recently, in Hongkong, a variety of the chicken influenza virus, considered until then as specific to the chicken, was shown to be infectious for man, producing, in some cases, a fatal evolution.

In South America, many new viruses, especially arboviruses (transmitted by arthropodes), have been described in the last decades in the Amazon region. The most frequent is Oropouche responsible for a benign acute infection but producing frequent epidemics in the Amazon region. The silvatic cycle is maintained by insects Culicoides in primate hosts and human infections are accidental. Urban epidemics may occur with man to man transmission by the ordinary urban mosquito Culex. Other benign infection are produced by virus Mayaro, also harboured by primates in silvatic cycles transmited by the same vector as the silvatic yellow fever. Four new infectious agents have been described in the last five years in Brazil as responsible for diseases of frequent fatal evolution: the Sabia virus, producing a systemic fatal infection, a Hantavirus responsible for an acute pulmonary syndrome (also serologically detected in Paraguay and Argentina); the Rocio virus, provoking an acute encephalitis and a new species of *Haemophylus, H. aegyptus*, provoking a purpuric fever. Scientists from the Arbovirus laboratory of the Evandro Chagas Institute in Belem, have isolated, in the last decades, more than 200 species of virus (186 from the Amazon region) from which at least 37 were shown to produce human infections. The more serious are represented by dengue and yellow fever. Dengue was absent from the country after the control campaign against Aedes aegypti which succeeded in eradicating the mosquito in 1955. With the reintroduction of Aedes in the country in the 70-80ties, a first epidemic of dengue occurred in 1982 in Boa Vista, Roraima, in the frontier with Venezuela and affected 12.000 persons. But the Aedes mosquito had already invaded all the territory and in the following years the epidemics spread over the country: 40 thousand cases in 1990 (most of the Northeast and Southeast areas), 97 thousand in 1991, with more than 78 thousand in the city of Rio de Janeiro, more than 500 thousands in 1998, with a pandemic distribution all over the country, with exception of the extreme southern States (Rio Grande do Sul and Santa Catarina). The situation is now more serious by the fact that three varieties of the dengue have already been identified in Brazil, which will eventually increase the incidence of haemoragic dengue with important lethal issues. After the erradication of the Aedes mosquito urban yellow fever disappeared from Brazil. The last epidemic occurred in 1928 in Rio de Janeiro. However the presence of silvatic yellow fever with primates reservoirs transmitted by silvatic mosquitoes is a permanent threat to the countries in the Amazon area, specially considering the re- invasion of Aedes in urban areas of the Amazon.

How do these new diseases appear? How do some of them spread so suddenly? These problems are the object of innumerous researches and speculation, but there is agreement in general about the animal origin of most of these "new" pathogens which were first circulating among wild animals and transmitted by arthropods or by direct contact and infect Man when he invades their natural environment. This can happen sporadically, as in the case of West equine encephalytis transmitted by *Culicidae* mosquitoes from their natural bird reservoirs. It can also happen systematically, as in the classic case of cutaneous and muco-cutaneous leishmania parasites, the natural host are forest of which rodents, transmitted by haematophagous insects from the group of *Phlebotomus. Leishmania* parasites infect people with frequent contact that have the forest. Most of the so called emergent diseases belong, therefore, to the classic category of Zoonosis. In a certain number of cases, the animal reservoirs are still unknown, as in the case of the EBOLA virus and the Sabia virus.

It must be added that the extremely versatile genetic material of virus and bacteria permit, in some cases by simples point mutations, the appearance of adaptive variability allowing them to escape the natural non specific immune barriers represented by antibodies and cytotoxic cells like the "natural killers". In this case, a "new" pathogenic agent may arise from a previously known one. The influenza virus from the "Spanish influenza epidemics" of 1918 had probably this origin. Among pathogenic bacteria, the capacity of exchanging genetic material has been shown, even between quite different species, through plasmids, phages or even directly by conjugation. This phenomenon plays an important role in the transference of foreign DNA sequences containing genes conferring resistance to antibiotics or promoting new virulence properties. The "virulence islands" described as circulating in various *Enterobacteria* species are examples of this kind of transfer, which seems, for instance, responsible for the virulence of *Vibrio cholera* 0139, the agent of the cholera epidemics in recent years.

As stressed by Lerderberg, we have not, today, many more tools than at the time of the Spanish influenza pandemic outbreak to defend ourselves against a series of infectious agents. On the contrary, we can say that, in some aspects, we are more exposed to this kind of accident for a series of reasons: the increase in number and rhythm of contacts and interactions of human populations; the degradation of human and natural environments by a wild search and exploitation of natural resources; the increased promiscuity in many human overcrowded communities, specially in urban areas, at the national and international levels. Finally, the phenomenon of invasion and occupation of new geographic sites, by the establishment of settlements in areas where Man was until now absent – forests, deserts – thanks to the new and powerful tools of intervention.

Brazil is a good example of accumulation of all the above factors. In what concerns population interactions, it must be recalled that a few decades ago, most of the international frontiers zones (with exception of those with Argentina and Uruguay) were sparsely inhabited and that population exchange was practically absent; the access to the Amazon region was possible only through the river, with fluvial navigation poor and limited; Central areas of the country (where now flourish Brasilia and Goiania, important urban communities and modern agriculture settlements) were poorly inhabited; Communication between South and North – North east areas of the country were practically dependent on maritime routes through the Atlantic Ocean, as all international communication. With the building of Brasilia, the opening of the Brasilia-Belem road (1961), the construction of the Trans-Amazonian road network (1970) and the development of air transportation traffic, these conditions have been dramatically changed. Travelling by air in Brazil increased from 6 million passengers/year in 1970 (only 350 thousands international travellers) to 39 million in 1996 (with 10 million international travellers). The Trans Amazonian road network allowed access to the frontier zones of the Guyanas, Venezuela, Colombia, Peru and Bolivia promoting an increase in human interchange and intense internal migratory movements of populations originating from the most diverse areas of the country, particularly in two directions: 1) From the North-east rural areas to South-east urban areas, resulting in megalopolis development of Sao Paulo and Rio de Janeiro; 2) From all rural areas of the country, particularly from the South and North-east regions, to the new colonisation areas of the Amazon region: people were attracted by the offer of land for the new agricultural settlements, and the open gold mining opportunities along the Amazonian basin. Thus a substantial increase in the population at the frontier zones came about. In Rondonia (Bolivian border) the population increased from 110 thousand inhabitants in 1970 to 1.5 millions nowadays; in Amapa (border of the Guyanas, from 130 thousand to 400 thousand and in Roraima (Venezuelan border) from 50 thousand to 300 thousand.

These new conditions have already had epidemiological consequences: the re-invasion of the country by *Aedes aegypti*, which had been eradicated in the 50ties, took place through the north (French Guyana) and west (Paraguay and Bolivia) borders; the consequent penetration of dengue (nowadays spread all over the country) also took place at the north border. Another example is the recent cholera epidemic (1995-96) that penetrated the Amazon region through the border area with Peru and now maintains and endemic presence in various areas of the North and North east States. The explosion of malaria in the Amazon region (50 thousand cases in 1961 and 500 thousand cases in 1990) was the result of wild migration, deforestation and colonisation of the new Amazon areas starting in the 70ties. It is interesting to observe that, the intense migratory movement, people coming to and going from the Amazon region to other places (especially gold mining adventurers), has been producing, in recent decades, short sporadic malaria epidemics in practically all regions of the country. The dramatic impact of these migrations in many Indian communities must also be reminded, with the introduction of respiratory infections, tuberculosis, malaria and other pathologies that have ravaged a series of Indian communities.

As already signalled, the accelerated and bewildering urbanisation, with the formation of megalopolis areas in Sao Paulo and Rio de Janeiro, devoid of basic sanitary infrastructure and overcrowded by population of low income, bad nutritional conditions and poor health care, are also responsible for the emergence and re-emergence of a series of diseases like tuberculosis, leprosy, cholera, infantile diarrhoea and pulmonary infections, dengue etc. It is relevant to observe that even some pathologies considered as classical rural infections are now invading urban areas. That is the case of malaria in Manaus and other cities in the North region and the appearance of cutaneous and muco cutaneous leihmaniasis in urban areas of Rio de Janeiro. These phenomena could be imputed to a degradation of environmental and sanitary conditions in urban areas.

In summary, emergent diseases constitute a large group of human pathologies, some of which are really new and have recently appeared, others that are still to come and finally others which are old companions of Man and, for reasons of genetic adaptive mutations, genetic exchanges and/or changes in the process of transmission (either of biological origin or socio-economic nature) are re emerging. All of them appear or reappear as serious problems of Public Health and even – at a maximalistic point of view – as threats to Human survival on Earth. Examples in the past are known. Small-pox has produced ravages in Middle Age communities. Plague, which was sporadically endemic in the Middle Age, produced ravaging epidemics in the beginning of Modern times when, after the introduction of potatoes in Agriculture, the construction of silos provoked the proliferation of rats in close contact with Man.

If, in recent years, the social and economical factors described have aggravated the threats of emerging diseases, from a biological point of view we must consider emerging diseases as a normal and permanent aspect of the Human adventure in the Planet. Since *Homo sapiens* appeared on Earth, he has been fighting against microbes and viruses inherited from the precursors of Man in the evolutionary scale or attacked by other pathogens originated from biological concurrent species in the hard reality of the Darwinian world. Until recently, this fight on the human side was dependent only on natural weapons provided by the immune system. With the development of Science and of human knowledge on the nature of disease, which led to the development of new tools and to the formulation of strategies for defence against infection, it became possible to interfere in the natural selective process represented by emerging diseases. This is the subject of the following considerations in this text.

From what it was said above about the complex nature and origin of emerging diseases, it can be concluded that defence strategies must involve measures at several levels: social, economical, urban, environment protection and planning, education, scientific and technical research, sanitary and medical measures etc. Therefore it concerns all levels of public administrations and the participation of numerous public and private organisms and Institutions.

At technical and professional levels the activities necessary for the formulation of strategies against emerging diseases have the following objectives: 1) to identify, clarify and define specific pathologies that represent threats and problems to specific areas and regions; 2) to create and organise operational structures, to take charge of the training of the operating agents and the decision makers; 3) to maintain a high level of scientific activity in training and research necessary permanent epidemiological surveillance of known pathologies and the identification of emerging ones; and finally, 4) to perform a permanent critical evaluation of the applied measures. Two sectors of the Society are equally responsible for the undertaking of these activities: the sector of Public Health, represented essentially by governmental structures and Institutions and; the sector of Science and Technology in the Health Sciences, represented by Research Institutions and Universities with their complex national and international networks.

To the Public Health sector belong, in principle, the responsibilities of running epidemiological and sanitary surveillance through a network of structures held by technical staffs able to detect the appearance of new pathologies and/or of departures from the normal course of the old ones. These structures must also be able to intervene to check or control their evolution, triggering off central technical structures at the national or international levels when necessary.

In Brazil, the situation in this respect, as in many other matters, is quite heterogeneous as a function of the geographic areas considered, reflecting the profound regional and social inequalities of the country. While the epidemiological and sanitary surveillance would be, in principle, a responsibility of the Federal Government foreseen by the Constitution, in reality, in the rich South and South-east areas of the country, these functions have practically been taken over by State and Municipal Health administrations. In the rest of the country the function is undertaken by the National Health Foundation (FUNASA), which suffers from its original sin of a vertical centralised organisation. FUNASA, indeed, originated in 1990 from a successive fusion of vertical centralised structures created in the 40ties and 50ties to control individual diseases under the denomination of National Service of Malaria, National Service of Yellow Fever, of Plague, of Tuberculosis and so on. Each “Service”, in the past, took over all the responsibilities concerning individual diseases and suffered from both the artificial division of competence and fitness (by disease) and an equally artificial mixture of functions (epidemiological surveillance, operation of control measures and health and medical care of affected people).

In recent years, following the large national discussions and debates around the new Constitution of 1988, involving scientists, physicians, Public Health experts and technicians, the need for decentralisation of responsibilities in Health Services became consensual. The newly formed Unified Health Services (SUS) adopted the principle of transferring to Municipalities and State’ administrations the activities concerning Medical Care of the population, keeping at Federal level the responsibilities of the National Health Foundation (FUNASA) in epidemiological and sanitary surveillance and in running vaccination campaigns, vector control measures and other activities concerning control of endemic diseases.

Again, the extreme regional and social inequalities in the country made it difficult to implement these projects. In the rich South and South-east areas of the country, Municipalities and States have already taken over the responsibilities of providing Medical Care for the population. However, in the poorest areas in the North, North-east and Centre-west, as well as in parts of South and South-east regions, Municipalities have neither the resources and nor the technical capabilities to assume these functions, while the respective States do not have the necessary competence for the recruitment and training of the necessarily complex staffs. It is, therefore, inevitable that the Federal Government maintain its presence in these functions and organise, in collaboration with the States, a long term project to organise and qualify State and Municipal Health Services.

In what concerns specific Public Health responsibilities, FUNASA has not been able to carry out conveniently the specific role and functions of sanitary surveillance, in spite of the large number of employees in its body. However, FUNASA has not inherited and did not create appropriate physical structures and human expertise in the field. Most of its personnel has been trained for diagnosis and treatment of endemic diseases specific to each region, which means malaria in the North, schistosomiasis in the North-east, leishmanaisis in various areas. A minor fraction of the personnel has been trained in vector control specifically directed to malaria, Chagas disease, dengue and yellow fever and schistosomiasis. A more rational role has been maintained by FUNASA in the organisation of the National Campaign of Vaccination for children which has known a large success and is developed by health unities of States and Municipalities, supervised and co-ordinated by FUNASA.

A large and profound reorganisation of FUNASA's structure and functions is proposed by the VIGISUS project, now in the phase of discussion and implementation at the Ministry of Health. The project proposes a period of four years for the transfer to States and Municipalities of all the activities related to Medical Care of the population and also most of the functions related to Sanitary epidemiological surveillance and control of endemic diseases, including, therefore, emerging and re-emerging ones. In the original project the function of FUNASA, at the its higher level in Brasilia would be "to coordinate the National System of Health Surveillance, with the function of establishing principles, rules and orientations, to search, obtain and analyse information concerning Health conditions and to stimulate and sustain research in Health Sciences".

In spite of the conceptual progress represented by this new approach to define responsibilities, functions and roles of administrations and Institutions at different levels, these definitions have not yet brought sufficient information on the functioning of the future National Health System of surveillance. Indeed, one can argue against an excessive decentralisation and the proposed limitations in the functions of the central administration of the System. In relation to emerging diseases, for instance, we referred above to their sudden appearance and reappearance at any time and at any place, without respect for municipal, state, national or international frontiers, calling, sometimes for a urgent mobilisation of human competence, physical and intervention tools, which demands a network of structures like laboratories, hospitals, pharmaceutical industries, communication tools and instruments at the national level. In many cases the intervention needs the activation of mechanisms at the international level (access to information, collaboration and help of technical capabilities, access to new technologies). These measures are possible only through the initiative of the Federal Government. It must be reminded that the United States of America, known as an example of decentralisation and private initiative, in what concerns Health surveillance has the world's most centralised, authoritarian and interventionist structure at the Federal level – the CDC – which keep all responsibilities of Disease Control – being or not emergent. In Europe, the corresponding structures are less strict. Paradoxically, France, well known for its centralised administration, has, in the Public Health System, a more decentralised and heterogeneous structure, with a network of laboratories at the regional and departmental level, with a multitude of Reference Centres belonging to public administrations, Universities, Research Institutions like the Pasteur etc. This, however, is tightly connected by central structures with capability for intervention and able to activate the mobilisation of human and technical resources from the periphery.

In Brazil there is yet no clear definition on the structures and mechanisms to be adopted and on the necessary evolution of the existing structures, as well as the new ones that must be created. With the VIGISUS project, that will be supported by important national and international resources, new opportunities are offered for developing the National Health System of surveillance. This will need the active participation of the scientific and technical community in Health Sciences in close contact with the Public Health administration. The development of pilot projects will be necessary to adapt the different structures of the National System to regional and local peculiarities as a function of the referred regional and social inequalities.

However, in any of the possible alternatives for defining the general organisation of the National Health System of Sanitary surveillance, more or less centralised, the basic essential factors necessary for its correct and competent functioning are two: the presence of adequate physical structures covering the national territory and the presence in these structures of competent and trained staffs. In this respect, it is necessary to recognise that the country disposes neither of adequate structures nor of enough adequately trained personnel. How should these deficient points be overcome? To whom belongs these responsibilities? We have come, therefore, to a final point concerning the general Politics of Health Science and Technology.

At the National Conference on Science and Technology in Health, held in 1994, with a large participation of the scientific and technical community, were defined general proposals and goals in the area. A critical evaluation performed during the Conference was able to characterise deficient areas, in particular "an immense gap between the teaching and research activities and the productive industrial activities". The original document (ref.) also stressed the "black hole in the transition areas of research to the activities of control of endemic diseases". Unfortunately, it is necessary to recognise that the holes and gaps still persist. Without a strong efforts of Universities and Research Institutions for training scientists, physicians, technicians and auxiliary personnel at all levels of laboratory and field activities of surveillance and control, the country will be unable to construct an efficient National Health System. Brazil has all the necessary Institutions capable of doing this. Political decisions of the Federal and State Governments are, however, missing to give enough priority to these goals.

Emergent diseases, as already discussed, are permanent problems for Humans on Earth. They stress the need for a permanent effort of research in biological and medical sciences. They also stress the need for training top scientists and technicians able to work in the border line of human knowledge to develop new tools necessary for the control of new appearing threats. However, for the efficient use of human scientific knowledge, it is essential to construct a National Health System of Sanitary surveillance that, in parallel with the permanent control of current endemic diseases, will have the capability both for developing improved tools to control these diseases, as well as the capability for control of emerging diseases.

Health and Environment

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I - Introduction

The concern with the environment is gaining increasing attention all over the world, in special since the decade of the 70ies. Porto (1998, p. 33), refers to a variety of factors conceived as threats for the human species:

- Exposure of different regions of our planet to high degrees of environmental degradation;
- Detection of ecological risks of global extent, affecting ecosystems to varying degrees and threatening the life of future generations;
- Increasing effects of pollution caused by industrial wastes, consumption and transports in urban-industrial regions, associated with problems related to basic infrastructure, sanitation and socio-environmental degradation, enhancing the social vulnerability of populations, especially in the developing countries;
- Expected lack of natural resources fundamental for the production of industrial and consumer items, demanding for strategies such as recycling and redefinition of models for the construction of a new ecological economy and
- Increasing political pressure practised by new social movements – groups concerned with fields such as industrial risks and environment.

A detailed examination of the question health and environment from the viewpoint of a peripheric economy and its specific aspects ranging from lack of studies and discussion of the problem to high incidence of risk situations - the dumping of effluents into rivers for example - is thus indicated.

According to Lacaz, several international initiatives resulted in a new approach to the subject in Brazil: in the late 70ies, projects directed to occupational health were contemplated by the World Health Organization (WHO). In 1983, the Pan-American Health Organization (PAHO) publishes a document entitled: "Programa de Acción en la Salud de los Trabajadores" (Programme for the Health of Workers); in 1975, the International Work Organization adopts in its 71st International Conference on the Work the "Convention and Guide for Health Services at Work", later ratified in Brazil in the Executive Act Nr. 127, of May 25, 1991.

In Brazil, the 70ies were marked by the upcoming discussion of the health/disease/work process in the context of social medicine. A number of different occurrences testify the social relevance of this topic: new technologies provoking new diseases; benzene contamination in petrochemical pools; intoxications caused by agrichemicals; inadequate working conditions for women, children and old-aged people (Lacaz, p.8).

Lacaz refers to the end of the military dictatorship and to the formation of strong labor unions as facts that stimulated the discussions concerning work environments harmful for Man. In this context we witness the estbalishment of the "Intersyndical Comission for Health and Work" in 1978, transformed into the "Intersyndical Department for Studies and Research on Health and Work Environment" in 1980. Two further events have to be emphasized: the participation of the "I National Conference on Health of the Workers" in the elaboration process of the Federal Constitution of 1988 and the "II National Conference on Health of the Workers", in 1994. The implantation of the "Center for Studies on Occupational Health and Human Ecology" of the Oswaldo Cruz Foundation, body linked to the Ministry of

Health, and several similar initiatives in other regions of the country constitute important facts occured in the 90ies.

This text intends to contribute in a non-exhaustive way with some thoughts to the question health and environment .

We will approach the interrelation between health, environment and economy, focus questions regarding industrialization, sanitation and risks resulting from technological development and conclude with some thoughts and suggestions for an agenda to be discussed in the forthcoming century.

Health, Environment and Economy

The frequent discussions arising today in the different social classes concerning social and environmental claims and questions related to health demand for a deeper understanding of the problem by comparing a variety of approaches and concepts. As explained by Porto (p. 34): "*All these approaches are mirrored in one basic challenge, the need for integration of global and local levels, of different fields of knowledge and different governmental, social and economical segments in the conformation of policies and actions capable of meeting the needs of each national or local reality. It was in the context of this unifiying perspective that, principally since the late 80ies, the concept of a sustainable development was created and promoted, aiming to integrate the problem environment and development, even if in a not very clear and sometimes contradicting manner. International events like the RIO 92 are examples for the attempt to establish agreements and international agendas under the leadership of international organisms such as the United Nations Organization (UNO) and the World Health Organization (WHO)*".

Special attention should be given in this context to the conformation of national models through the elaboration of scientific-technological, health and environmental policies privileging interdisciplinary and intersectorial approaches capable of favoring and stimulating the development of each nation. A *sine qua non* condition for the achievement of a sustainable development is the harmonization of macroeconomic and specific sectorial policies - industrial, scientific, technological, urban, agricultural, related to transports, among others - from the point of view of health and environment (ibidem, p. 35).

In the attempt to minimize the social and environmental inequalities today characteristic for the economy in the world, especially in the recently industrialized countries like Brazil, the historical, economical and cultural realities of each region and country have to be understood without detaining oneself in preconceived models of the environmental question. The problems of the tropical regions and their mega-biodiversity are very different from those found in the richer regions of the northern hemisphere, great generators of technology. While the poorer nations sufffer from misery, the wealthy nations are concerned with questions such as global warming and the hole in the ozone layer (*ibidem,* p. 35).

The pressures for dis-regulamentation of the State imposed by increasing flow of international capital, the consequences of prolonged economical recession, the ongoing process of tributary adjustment represent increasing limitations for the elaboration of national projects and endanger the role of the State as formulator of policies, planner and regulator of health and environmental problems related to economical development. These difficulties are reflected in increasing polarizations claiming for restraint of public expenses, privatization of public enterprises, liberation of trade and investment and in regional pressures exercised by the working class and society in general for better life, working and environmental conditions. The speed of this process and the lack of forums for negotiation of the most important questions can, besides the present state of perplexity, create serious implications for the health and environment of the country, by reducing the power of the State to plan, formulate and coordinate inter-institutional and inter-sectorial policies; to implement industrial, scientific and technological policies compatible with sustainable development and specific regional aspects ; to organize health and sanitation services; provide for adequate levels of employment and just remuneration; develop control actions; enforce the adherence to the sanitary and environmental legislation in force and finally, to form professionals capable of carrying out such activities.

The risks involved in the loss of capacity of the State to implement environmental and health standards in its political, economical, technological and industrial policies, repassing the competency for these regulating activities completely to the private initiative - environmental control, for example - can lead to an even greater exclusion of society and degradation of the social, working and health conditions of the population.

The advent of the industrial revolution extending from Great Britain to other countries of the occident resulted in deep transformations in the social relationships and in the technical bases of human activities. The relationship between Man and his environment was changed markedly and, as a consequence, the objective and subjective conditions of human health and the sustainability of the environment (Franco & Druck, p. 62).

The relation between Man and work environment underwent modifications. The figure of the handicraftsman - owner of the means of production - disappeared and gave place to a mass of workers, always more increasing with the migrations from rural areas to the forming cities. New production systems were developed and executed in an intensive and predetermined rythm, potencializing pre-existing agressive agents as well as new " *interactive and of distinct nature -physical, chemical, ergonomic and organizational" (ibidem*, p.62).

The modification of the technical bases of the work process was only possible through the use of new sources of energy. Manpower passed to be substituted by steam and combustion of renewable and nonrenewable resources and nuclear energy for productive or destructive purposes. Machinery incorporated more and more technological innovations, gaining increasing potency (*ibidem, p.63).*

Along with the increase of the global production capacity, the natural resources - water, raw materials - were complemented by new synthetic, chemical and petrochemical materials - used in substitution of cotton, natural fibers, rubber, ceramics - resulting in industrial wastes to varying degrees hazardous for human life (*ibidem*, p. 63).

To talk with the authors' words:

"Socially and economically, this production model took in an always more concentrated and intese way the form of capital whose expansion and crises are today expressed in economical globalization , increased social exclusion and inequality of countries of the northern and southern hemispheres, rich and poor, as well as in the appearance and need for consolidation of local and global environmental problems, challenges left for the future by the XX century."

The use of space in the contemporanean societies took a new shape. Cities emerged, rural populations migrated to urban regions, *"investments were guided by factors such as disponibility of renewable and nonrenewable natural resources and labor cost". (ibidem, p. 63).*

The new urban agglomerations and the emerging industrial activities also caused environmental problems - carbon monoxide, different pollutants - more recently resulting in phenomenons like acid rain, depletion of the ozone layer and of nonrenewable natural resources (*ibidem, p. 65).*

As explained by Moimon (apud Franco & Duck, p. 65):

"Recent estimates indicate that only 12% of the industrial establishments of the developed countries, concentrating 20 % of the value added, are responsible for 2/3 of industrial pollution. A paradox and contradiction, having in mind that at present 80% of goods and merchandises produced by Man are consumed by less than ¼ of the population of the world."

Today, not only the question of social exclusion but also the great socio-political and scientific challenges in the construction of a solid development and just and acceptable life standards have to be taken into consideration. The forms of production and consumption engendered between the XVIII and XX centuries are not only affecting the use and manipulation of renewable and nonrenewable natural resourcers but also the conditions of human existence: *"their living and working space, their migratory flow, the situations of health and death: (...) there is a historical relationship betweeen industrial risks, environment and populational health, changing with the features of the different forms of civilization" (Franco & Druck, p.65).*

Health, Environment and Technological Risks

In the beginning of the industrialization process, technological development and its negative aspects affected in the first place the worker. Today the risks are universal, affecting not only the workers but the entire society as well as local and global ecosystems (Porto & Freitas, p. 60).

The concept of technological risks for the environment arouse in this context. The development of technologies involving chemical and radioactive substances and genetic engineering, points forward to new hazards for health and environment. (*ibidem, p. 60).*

The authors explain:

"Reconsideration of the question from a technological point of view will confront us with the need to analyse the questions related to the risks inside and outside the walls of the industries by integrating the problem occupational health and environment in general. The need for such integration becomes particularly evident when analysing the problems of the chemical industry: the fragmentation of policies and institutional actions represented by the environmental groups - responsible for the "outside" - and occupational health policies concerned with risks and common causes is absolutely articificial".

The increased complexity of effects caused by production processes upon the biologic and social life of the planet demands for an integrated approach to the question health at work and environment, fundamental for the study and solution of the risk situations. (*ibidem, p. 60).*

Today, in an atmosphere of strong economical competition, the production processes are always more automatized, industrial plants allow complex, sophisticated and quick processes, greater capacity of production, storage, circulation of different consumer items. In the case of the chemical industry, for example, "*the different steps of the production process - extraction, production, storage, transport, use and discard - contributed to elevated concentrations of chemical substances normally inexistent in not industrialized environments*". (*ibidem, p. 60).*

The speed with which technological innovations are introduced into the production environment frequently hinders the analysis and management of the consequently introduced risks. In the developed countries, strong labor unions, environmental groups and society are claiming for rigorous forms of social control (*ibidem, p. 60).*

From the point of view of Theys (*apud Porto & Freitas, p. 61*), "*The question technological hazards is of increasing importance for analysing the vulnerability of contemporanean societies for revealing different characteristics of social disorders as: loss of autonomy of the citizen in the control of risks; obscurity of facts in cases of accidents; exposure to multiple risks; fragility of the society in face of disasters; the impossibility to govern critical situations; rigid centralization of the technological systems, creating domino effects in different interdependent areas necessary for the functioning of these systems; the possibility of extremely high loss and damage involved, among others*".

In developing countries like Brazil the combination of social misery, poor distribution of income and deficient scientific-technological capacitation only worsen the risks created by the industrialization process.

Biosafety

The increasing development of biotechnology is provoking great changes in the dynamics of different industrial sectors. Adequate use of biotechnology can be of great benefit for the society - new drugs, reagents, diagnostication kits, vaccines and engineered plants. Safe development of these activities implies in the first place in standardised norms and procedures and on strict adherence to these regulations.

In the developed countries good laboratory practices[1] are adopted for more than 20 years. Studies on biosafety improved quickly. Today this topic makes part of the agenda of international organisms working in the construction of a basic framework of regulations aiming to harmonize the norms and procedures adopted by the different countries.

Many developing countries do still not dispose of consistent legal instruments dealing with this subject. The lack of such legislation, however, can expose a nation to the most varied interests, including the use of its territory for experimental activities considered unlawful in countries where biotechnology is legally controlled.

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[1] Further sources of information:
- Office of Science and Technology Policy, 1986. Coordinated framework for regulation of biotechnology: announcement of policy and notice for public comment. *Federal Register 51, p.23302-23393*;
- Organization for Economic Cooperation and Development, 1982.*Biotecnology, International Trends and Perspectives.* Paris OCDE;
- Organization for Economic Cooperation and Development, 1992. *Safety considerations for Biotechnology*, Paris, OCDE.

Possas, M.L.; *Salles Filho, S.L.M. & Mello,* A.L.A. O processo de regulamentação da Biotechnologia; Implicações para as Inovações na Agricultura a na Produção Agroalimentar. IPEA/PNUD, 1993.

In Brazil, the regulation of biotechnology began to be discussed in the late 80ies, following the international example. The process was initiated with the legislative bill, proposed in 1989 by the then Senator, today Vice-President of the Republic, Marco Maciel, and resulted in the Law for Biosafety, enacted in 1995.

In our understanding, the State has to play an active and fundamental role in this process through the control off all biotechnological activities involving any risk – agriculture, nutrition, human and animal health.

In Brazil, the first legislative bill was proposed by the Senator Marco Maciel in November, 20, 1989 (PL Nr. 114/91). During the 5 years the bill was proceeded in the Federal Congress two substitutions were proposed, one in 1992 and one in 1994. The Law for Biosafety (Nr. 8.974) was ratified by the President Fernando Henrique Cardoso on January, 1995 but some vetoes resulted in the complementary Act (Nr. 1.752/96).

The Oswaldo Cruz Foundation, institution involved for almost one century in biomedical research played a fundamental role in the definition of the norms for biosafety. The original proposal elaborated by Specialists of FIOCRUZ in cooperation with technicians of EMBRAPA for the second revision of the law was almost entirely maintained and constituted the basis for the law presently in force.

Adherence to the established principles and norms allow research institutions, universities and industries to act with more responsibility in protection of our society. Besides that, the adherence to international quality standards favors the establishment of technological cooperation projects and grants the particpation in the international market, fundamental in a globalized world.

The Law for Biosafety (Nr. 8.974) of January 5, 1995, regulating § 1 of article 225 of the Federal Constitution estbalished safety norms and control mechanisms for the use of genetic engineering techniques in the construction, cultivation, manipulation, transport, commercializing, consumption, liberation and discard of genetically modified organisms (GMO), aiming at the preservation of life and health of humans, animals and plants and the environment.

The Act Nr. 1.752 regulating the Law Nr. 8.974 of January 5, 1995, disposing about the competency and composition of the National Technical Commission on Biosafety was ratified on December 20, 1995.

In spite of the progress in the legal aspect of the question, the basic structure of the organizations continues precarious, demanding for substancial investments. Besides the need for capacitation of human resources on technical and management level it is necessary to foster the implementation of working groups in different disciplines: economy, public policies, biology, chemistry, safety, management, among others. Few studies are carried out about risk evaluation methods, fundamental for providing a scientific basis for the emotional discussions about use and consumption of transgenic products.

Final Considerations

The serious social, sanitary and environmental situation in Brazil demands for articulation of corrective measures and projects for regional planning and development, meeting the needs of the country and future generations.

We have to invert the logic of the traditional economic policies, inclined to satisfy the demands of the big enterprises and of the medium and high social classes of the urban populations, to the detriment of the populations living at the margins of the big centers and the small rural producers.

This reorientation of the development model implies necessarily in the creation of a regional job market, reducing the still extense migration to the big and increasingly problematic urban centers. The development of regional competitive economic activities, socially and ecologically sustainable, requires better equilibration of the different levels of power and increased capacity of local and regional planning and actions, together with greater participation of the population in the decision processes, essential in participative democracies.

Based on a diagnosis of the present conditions of the developing countries, it is possible to propose integrated actions of the sectors health and environment, involving the following aspects:

Professional qualification – should occur through the establishment of cooperations involving post-graduation courses *latu senu* and *strictu sensu.* The development of interdisciplinary contents and methodologies should be encouraged, specially with regard to the formation of docents in fields such as health, environment, sanitation, biosafety and hydric resources.

Information systems – health and environmental information systems should be strengthened. The integration of the different systems should be favored through adaptation of concepts, spaces and methods. The improvement of indicators and development of specific indicators for the quality of life, associated with indicators for the quality of water, air, soil, levels of noise etc. besides systematization and quick dissemination of information should make part of these actions. The same way, the definition of combined indicators for life and health conditions, including social violence, and respective information systems should be encouraged.

Education – strategies should be elaborated for the promotion of formal and informal health and environmental education activities and programmes, capable of promoting sustainable development.

Research and technological development – systematic evaluation of form and degree of use biomedical research results in the implementation of public health actions; evaluation of the effects of research and technological development upon the improvement of methods of environmental control; evaluation of the contribution of scientific-technological development in general to sustainable development; implantation of mechanisms favoring interdisciplinary studies on the relation health/ environment including complex systems. All these efforts should be associated with the establishment of priorities, incentivated and encouraged by the financing agencies as well as with the engagement of researchers with this agenda. Resarch and the development of appropriate technologies in search of equal socio-economical, environmental and health conditions in all regions of the country should be encouraged

Bibliography

Franco, T. & Druck, G. Padrões de industrialização, risco e meio ambiente. *Ciência e Saúde Coletiva,* Rio de Janeiro, 3(2): 61-72, 1998.

Lacaz, F.A.C. Saúde dos trabalhadores: cenários e desafios. *Ciência e Saúde Coletiva,* Rio de Janeiro, 3(2): 7-20, 1998.

Poto, M.F.S. Sáude, ambiente e desenvolvimento: reflexões sobre a experiência da COPASAD – Conferência Pan-Americana de Saúde e Ambiente no Contexto do Desenvolvimento Sustentável. *Ciência e Saúde Coletiva,* Rio de Janeiro, 3(2): 59-72, 1997.

Energy and Sustainability

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I - Introduction

Energy is a concept invented by physicists to measure the capacity to perform work which is necessary to move things around and perform other activities that are characteristic of human behavior such as growing food, its metabolism when we eat, building shelter, transportation etc.

The good functioning of the "human machine" i.e. the "primitive man" in the forest requires approximately 2,000 kilocalories of energy per day (24 hs). This is the energy contained in a cup of petroleum Such energy is spent at the rate of 100 watts, equivalent to the electrical energy needed to keep a regular size lamp "on".

The presence of energy is ubiquitous in all human activities and as agriculture, commerce and industry developed the energy consumption grew hundred fold from the 2,000 kcal/day mentioned above to more than 200,000 kcal/day which is the average consumption of the "technological man" in the United States today (Figure 1).

The world's average energy consumption is 30,000 kcal/day i.e., 1,5 tons of oil equivalent (toe) per capita. With the current population of almost 6 billion people this leads to an overall consumption of approximately 8 X 10^9 toe.

Such large energy consumption coming mainly from fossil fuels (coal, oil and gas) poses two basic problems concerning the sustainability of the present "energy system":

- exhaustion of available resources;
- environmental problems caused by the use of fossil fuels

II - Available Resources

The evolution of energy resources consumption in the last 150 years is shown in Figure 2 which indicates that fuelwood was the main resource until 1880 being rapidly replaced by coal which in turn was partially replaced by oil, then gas, more recently nuclear energy and to a small extent by solar technologies.

Fuelwood - of paramount importance in the past - was always used rather inefficiently for cooking, heating and more recently for steam production and electricity generation. Such use led to a considerable depletion of natural forests which were not regenerated. Because of that, a renewable resource - which could be used in a sustainable way - was wasted. As we will discuss later there is a revival of the use of fuelwood with modern efficient technologies.

Fossil fuels (coal, oil and gas) became the dominant source of energy and account today for more than 80% of all commercial energy used around the world. Reserves of such fuels are large but not infinite and therefore their continued use is not sustainable as can be seen in Table 1 which gives the world estimated reserves and the expected duration of such reserves if present patterns of consumption persist.

Oil and gas reserves are not expected to last for more than 50 years but coal might last for another 200 years which means several generations. In a human scale this approaches sustainability since in all likely hood alternative energy technologies will be developed in that timespan.

The problem with fossil fuel is therefore, not strictly, one of exhaustion but one of the environmental degradation it produces.

Nuclear energy was considered, until the middle 70's, an attractive option for the replacement of fossil fuels for the generation of electricity and indeed it reached a point of accounting for 16% of all generated electricity in the 80's. In the early 90's the share has increased to 17% but it is evident that this rate of growth is much smaller than the rate of growth observed in the early 80's (14.3% share of global electricity production in 1985 compared with 8.2% in 1980) as shown in Figure 3. Safety problems and cost escalation - due in part to such concerns - led to an almost complete freeze in the construction of new nuclear reactions as shown in Figure 4 and therefore to a leveling of the electricity generated.

Barring a revival of nuclear energy such option seems to be slowly being relegated to be a reduced contribution to the world electricity generation which is growing rapidly in developing countries at approximately 6% per year. Electricity generation in the world has been growing at 3.2%/year.

III - Environmental Problems

The extensive use of fossil fuel has generated the most serious environmental problems faced by industrialized regions of the world (Table II).

These are not new problems: coal was used widely in England in the 16th century and London, particularly, was affected by serious "episodes" of air quality at that time. The persistence of such problem until recently led to the adoption by the United Kingdom in 1956 of the Clean Air Act after a very serious "environmental fog incident" in 1952 which caused 4,000 deaths and more than 20,000 cases of illness.

After the adoption of such Act other countries followed the same path particularly the United States with the Clean Air Art of 1970 which opened the way for the establishment of EPA (Environmental Protection Agency) and Ministries of Environment around the world.

The main pollutants emitted in the combustion of fossil fuel (coal and oil) are sulphur and nitrogen oxides, carbon monoxide, suspended particulate matter and ozone (natural gas is significantly better in that regard). Such pollutants are responsible for "smog" in cities and are responsible for "acid rain" which sometimes is precipitated hundreds of kilometers from the place where the pollutants originate, crossing, sometimes, national boundaries. In addition to that, combustion of all fossil fuel (gas included) produces CO_2 which is the most important contributor to "greenhouse warming".

These are the concerns that are putting a lot of pressure to reduce fossil fuel consumption and the recent Kyoto Protocol on greenhouse gas emissions reflects such concerns. According to this Protocol the industrialized countries will reduce - by the year 2010 - their emissions by 7% bellow their emissions in the base year of 1990. This is a substantial reduction since the emissions of such countries have been increasing approximately 1% per year since 1990.

Efforts to reduce environmental degradation are therefore leading a reduction in consumption of fossil fuels which is consistent with efforts to make them last longer, giving thus more time for the development of new sustainable technological solutions that will eventually replace them.

What are those solutions?

IV - Renewable Energies

Renewable energies are all solar energies (wind, photovoltaics, solar thermal, biomass and hydro) and therefore inexhaustible. In addition to that, they produce a minimum of pollutants and their use could lead to a sustainable energy future if they could produce enough energy to replace fossil fuels presently in use at an acceptable cost. We have not reached that stage yet.

Tables III and IV give the most important available technical characteristics of renewable energies.

As one can see in these tables commercial[1] renewable energies (excluding hydro energy) account today for approximately 35,000 MW of electricity which is only 2% of the total in use in the world and less than 1% of the liquid fuels in use.

The cost of renewable energies is higher than energy from fossil fuels (or hydro and nuclear) but such cost is falling according to 'learning curves" that look quite promising.

For example, Figure 5 show the decline in cost of photovoltaics, one of the most promising of all renewable sources. In 1975 the cost per MW was US$80,000 which fell 20% for each doubling of production. Present cost is US$3,000/kW and will probably be competitive to other sources at US$l,000/KW in 5 or 10 years.

Another very promising source is biomass which still represents some 20% of all the world's energy consumed mainly in rural areas of developing countries as fuelwood and charcoal. The very low efficiency in the use of biomass which has been commonplace can however be improved substantially either by gasifying or liquefying it before burning.

Although geographically well placed extensively direct solar energy either through photovoltaics or thermal energy, the utilization of solar energy in Brazil is mostly done through the use of biomass either as ethanol or by the use of biomass for the generation of electricity.

The Ethanol Program

Ethanol is produced from fermented sugarcane juice and used as a substitute for automobile gasoline in Brazil. Approximately 200,000 barrels per days of ethanol are used, reducing the amount of gasoline needed for the 16 million - automobile fleet by 50 percent. Although it has a lower caloric content than gasoline, ethanol is an excellent motor fuel: it has a motor octane number of 90, exceeding that of gasoline and it is suitable for use in higher compression engines (l2:1 versus 8:1). The development of high compression motors in Brazil constitutes an example of technological leapfrogging by itself.

The expansion of sugarcane plantations from less than 1 million hectares in 1975 to 4 million hectares in 1990, and the construction of nearly 400 processing plants to produce large quantities of ethanol, have resulted in the creation of approximately 700,000 jobs. The initial environmental problems encountered by the distilleries -

[1] Most of low quality biomas energy (fuelwood, dung, food residues) are used without involving commercial transaction. The proper evaluation of this amount of energy is difficult, but some evaluations claim that this represents 10% of the total world energy consumption.

such as the disposal of liquid effluents and bagasse (dry residue) have been solved by converting the stillage into fertilizers and using bagasse to generate electricity.

In addition, the substitution of ethanol for gasoline avoids emissions of 9.45 Mt of carbon per year, corresponding to 18 percent of all carbon emission in Brazil.

This is a very significant result contrary to the one obtained in the US with the production of ethanol from corn. In this case fossil fuel is used extensively for the processing of ethanol, such is not the case of Brazil where bagasse is the fuel used. Both ethanol and bagasse are renewable energy sources.

The estimated remaining amount of bagasse and other agricultural residues from ethanol production is estimated to be 4 Mt/yr of dry matter, a significant portion of which is or could be used for electricity generation.

Ethanol production increased from less than 3 billion liters per year in 1978 to 12.6 billion liters per year in 1995 (Figure 6).

In the initial phase of Brazil's ethanol program, the cost of production was very high and ethanol could only compete with gasoline if supported by heavy government subsidies.

Figure 7 shows the cost evolution of ethanol from 1981 to 1995. Between 1981 and 1987, ethanol price declined moderately (PR=70%), from 1987 to 1990 it decreased very quickly (PR=50%) and after 1990 it practically stagnated (PR=90%).

The expectation that alcohol prices would drop to make it competitive with gasoline did not materialized which led to serious problems. Present prices paid for ethanol from sugar producers are very high, US$400/$m^3$ (tax excluded) shich is almost twice the price of gasoline. Approximately US$2 billion per year is being collected from the consumers to guarantee ethanol production. Since its inception the fuel price policy adopted to open the way for the use of ethanol was the following: the Government indexed the consumer price of alcohol to the price of gasoline and charged for gasoline a price which was approximately double the price in the United States. The proceedings of this "tax" on gasoline were used to reduce the cost of other petroleum derivatives (LPG and nafta) and in the case of ethanol to cover its higher production costs. The justification for such a policy was the beneficial environmental and social consequences of petroleum substitution.

Ethanol from sugarcane is also used in Zimbabwe. It could play an important role in Cuba and other sugarcane producing countries.

Gasification and Electricity Generation from Biomass

Burning fuelwood, bagasse and other agricultural residues to produce steam and generate electricity is a proven technology used in many countries. In the United States, some 8,000 MW of electricity is generated from biomass. However, present systems in operation in sugar mills use low pressure boilers with efficiencies of under 10 percent. The most basic improvement is to use condensing-extraction stream turbines (CEST) at higher pressures. These systems can achieve efficiencies of up to 20 percent.

Advanced technologies have been proposed to convert solid biomass into a low BTU gas through gasification and then using this gas to power gas turbines. Efficiencies of higher than 45 percent can be expected from a biomass integrated gasifier/gas turbine (BIG/GT) system The merit of BIG/GT systems is the ability to provide high efficiencies in units of a size suitable for biomass fuels (20 - 100 MW).

In a 25 MW demonstration plant in Brazil, supported by the Global Environmental Facility, General Electric has adapted its aero derivative turbines for low BTU gas and a Swedish company has developed atmospheric pressure gasifiers. Shell Brazil and local electricity companies are also shareholders in the pilot plant. Once developed and fully tested, the technology could be used worldwide. Producing fuelwood in large "energy farms" will be particularly significant to rural development efforts and employment in developing countries.

V - The Future

Projections have been made of the possible role of renewable in the next few decades by different groups.

One of the most interesting of them is the one produced by the World Energy Council (WEC) which constructed different scenarios ranging from "business as usual" to an "environmentally driven" scenario in which public policies are introduced to enhance the contribution of renewables. Another important projection is RIGES (Renewable Intensive Global Energy Scenario) which tries also to maximize the contribution of renewables including different types of new technologies in development.

A comparison of these scenarios is given in Table V.

In a "business as usual scenario" the contribution of commercial renewables will not surpass 10% in the period 2020-2025. While in the WEC Scenario it is 30% in 2020 and 45% in the RIGES scenario in 2025.

If these projections are fulfilled by 2025 one would not reach a sustainable energy supply but will be well underway to reach it in the following few decades.

Table I: World Energy Consumption and Proven Reserves (1991)

PRODUCTION	TEP X 10^9	Reserves/Production (in years)
Coal	2.16	209
Oil	3.11	45
Natural Gas	1.78	52
Hydro Electricity	0.19	renewable
Nuclear Electricity*	0.53	very long
TOTAL	7.78	

* *efficiency of 30% in the conversion to electricity*

Table II: Human Impact on the Global Environment Portion Attributable to Energy Supply*

			Portion of Human Disruption Caused by			
Affected Quantity	Natural Baseline	Human Disruption Index**	Industrial Energy	Traditional Energy	Agriculture	Manufacturing Other
Lead Flow	25,000	15	63% fossil fuel burning including additives	Small	Small	37% metals processing, manufacturing, refuse burning
Oil Flow to Ocean	500,000 tons/yr	10	60% of oil harvesting, processing, transport	5% burning traditional fuels	12% agricultural burning	70% metals processing, manufacturing, refuse burning
SO_2	50 million tons/yr	1.4	85% fossil fuel burning	1% burning traditional fuels	1% agricultural burning	13% smelting, refuse burning
Methane Stock	800 parts per billion	1.1	18% fossil fuel harvesting and processing	5% burning traditional fuels	65% rice paddies, domestic animal, land clearing	12% landfills
Mercury Flow	25,000 tons/yr	0.7	20% fossil fuel burning	1% burning traditional fuel	2% agricultural burning	77% metals processing, manufacturing, refuse burning
Nitrous Oxide Flow	10 million tons/yr	0.4	12% fossil fuel burning	8% burning traditional fuels	80% fertilizer, land clearing, aquifer	small
Particle Flow	500 million tons/yr	0.25	35% fossil fuel burning	10% burning traditional fuels	40% fertilizer, land clearing, aquifer disruption	15% smelting, non-agricultural land clearing, refuse burning
CO_2 Flow	280 parts per million	0.25	75% fossil fuel burning	3% net deforestation for fuelwood	15% net deforestation for land clearing	7% net deforestation for lumber, cement manufacturing

** Energy systems account for a significant portion of the human impact on the environment through emission to toxic and other pollutants in amounts rivaling or exceeding natural flows.*

*** The human disruption index is defined as the ratio of human-generated flow to the natural (baseline) flow.*

Source: (Holdren, 1990)

Table III: Technical Status of Renewable Energy Systems

Technology	Status	Technical Feasibility	Unit Size	Conversion Efficiency (%)
Active Solar Systems			1-50 MWt	25-50
• Heating	Commercial	H		
• Cooling	R&D	M/H		
Solar Thermal Power	Demonstrated	M/H	7-100 MWe	15-30
Photovoltaic Systems				
• Grid-Connected	Demonstrated	M/H	1-7000 kWe	10-25
• Off-Grid	Commercial	H	0.01-1000kWe	10-25
Biomass				
• Fuel	Commercial	H	n.a.	n.a.
• Power	Commercial	H	5-50 MWe	25-35
Wind. Power	Commercial	H	0.02-1.5 MWe	25-45
Small Hydroelectricity	Commercial	M/H	0.5-25 MWe	80-90
Ocean Wave and Tidal Energy	Commercial/R&D	L/H	3-10 MWe	n.a.
Ocean Thermal Energy	R&D	L	100-1000 MWe	n.a.

Notes: Wood combustion is commercial along with ethanol

MWt = megawatts thermal

MWe = megawatts electric

kWe = kilowatts electric

n.a. = not applicable or not available

L, M, H = low, medium, high

Technical feasibility, conversion efficiency and unit size are based upon current views. All of the tables shown are meant to convey a sense of progress and direction.

Table IV: Characteristics of Renewable Energy Sources

Technology	Current Estimated Cost		World Installed Capacity	Environmental Problems
	Capital ($/kW)	Total (cent/KWh)		
Active Solar Systems	2,500 - 3,000	15 - 20	US$ 650 million sales in 1991	small
Solar Thermal Power	3000	20 - 25	< 1000 MW	land constraints
Photovoltaic Systems	7000	25 - 35	500 MW 0.5 TWh in 1994	land constraints 1 MW 20 to 50,000m^2
Biomass Energy				no SO_2 but plenty of particulates
• Fuels	n.a.	30 - 35	15X10^9 liters/year	
• Power	1700 - 2000	7 - 15	10,000 MW	land use issues
Wind Power	900 - 1400	5 - 10	4,900 MW 7.5 TWh in 1995	visual pollution
Small Hydroelectricity	1000	5 - 10	5% of total hydro ~ 20 X 10^3 MW	small
Ocean Wave and Tidal Energy	1400 - 2500	15 - 20	–	?
Ocean Thermal	10000	30 - 40	–	?
TOTAL			35 X 10^3 MW and 12 X 10^6 toe/ of fuels	

All costs are expressed in US dollars per kW of peak electric power, operating and total costs are in US cents per kWh of electric energy delivered. Estimates refer to grid-connected installations, 30-year system life, 7 per cent real discount rate per year. Biofuels costs are provided in cents per liter of ethanol derived from biomass priced at US$ 3 a gallon; fossil fuel costs are between US$ 1 and 2/gallon.

One dollar = 100 cents

n.a. - not aplicable

TABLE V: COMPARISON OF SCENARIOS - PRIMARY ENERGY CONSUMPTION IN GTOE

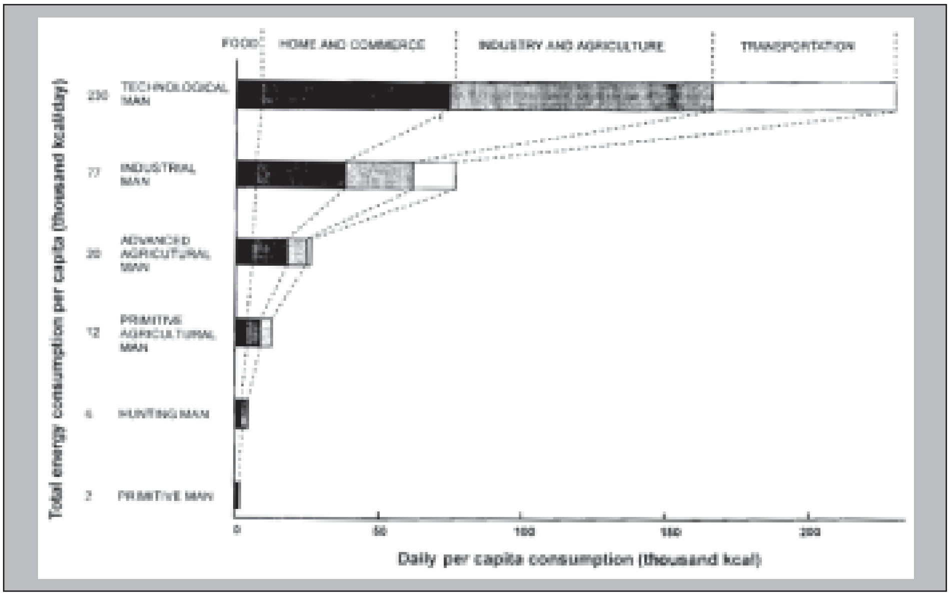
		WEC scenario C (year 2020)		RIGES (Year 2025)	
Fossil Fuels					
	Solid		2.1		2.00
	Liquid		2.7		1.72
	Gas		2.4		2.10
Nuclear			0.7		0.33
Renewables			3.4		5.02
	Largo hydro	0.9		0.68	
	New renewable*	1.4			
	Intermittent renewable			0.84	
	Traditional renewable	1.1			
	New biomass			3.3	
	Solar H_2			0.2	
Geothermal					0.04
TOTAL			11.3		11.21

Note:

In "new renewable", "modern biomass" contributes 0.6 GTOE. This category is considered "new biomass" in RIGES along with traditional biomass which is all converted into "new biomass" in the year 2025. The WEC scenario thus give 1.1 + 0.6 = 1.7 GTOE for "new biomass" in the year 2020. Subtracting 0.6 GTOE from "new renewable" in WEC reduces it to 0.8 GTOE for what RIGES considers "intermittent renewables". This compares well with 0.84 GTOE in the RIGES scenario.

Figure 1

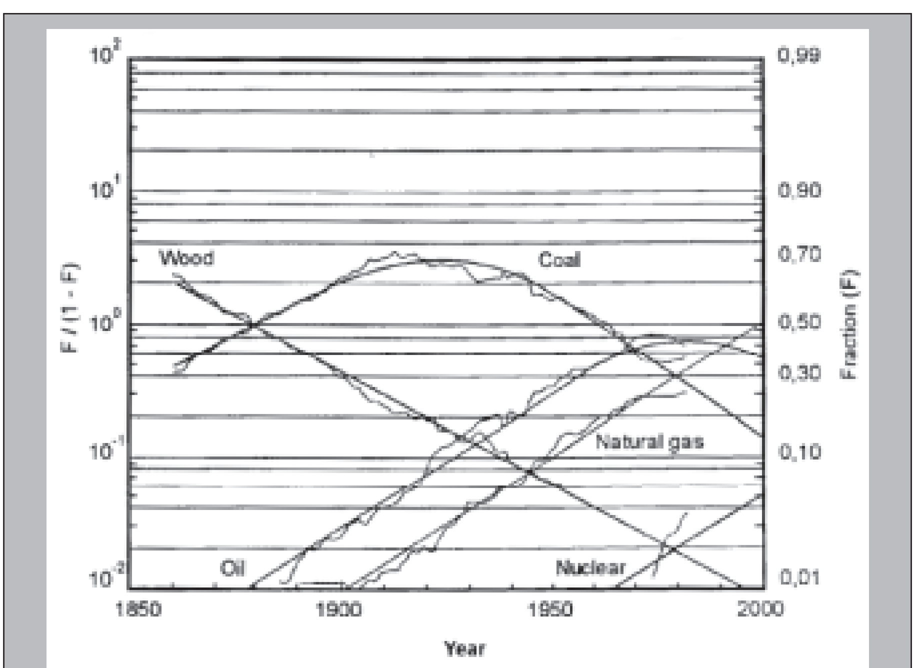
Stages of Development and Energy Consumption



Source: Cook, E., Man Energy Society, W H Freeman and Co. , San Francisco, US (1976)

Figure 2

Historical Market Penetration Curves for Various Fuels



Note : Fraction (F) is the fractional market share.

Source: Nakicenovic, N. et al (eds), "Long-term Strategies for Mitigating Global Warming", Energy, 18, 401 (1993).

Figure 3
Growth of Nuclear Electricity Generation Since 1970

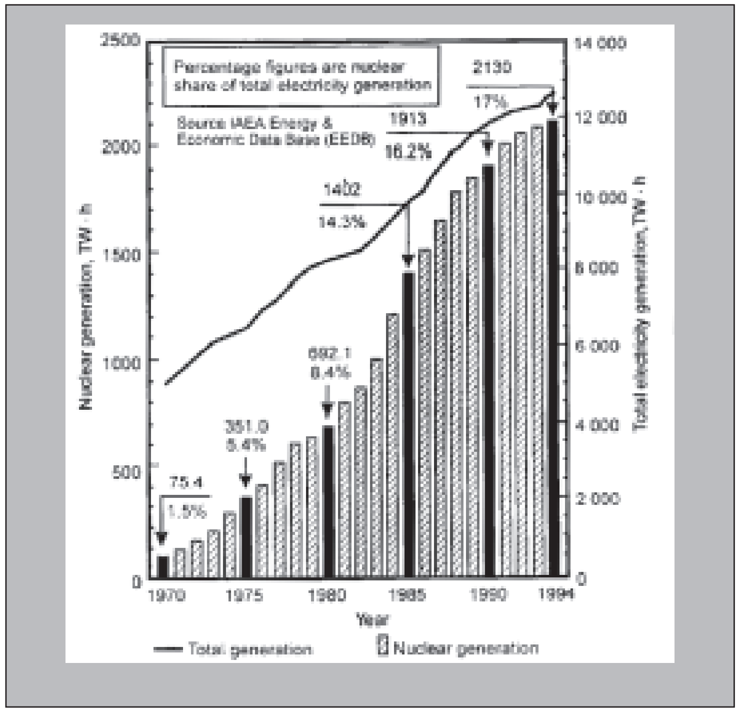
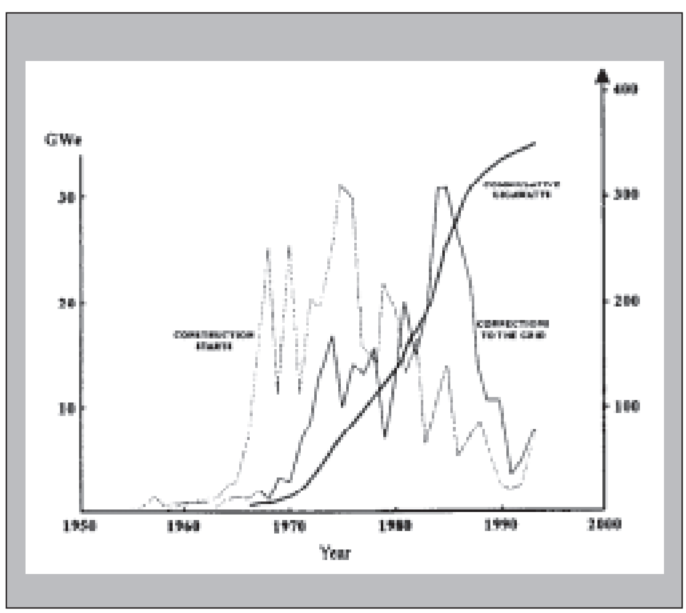
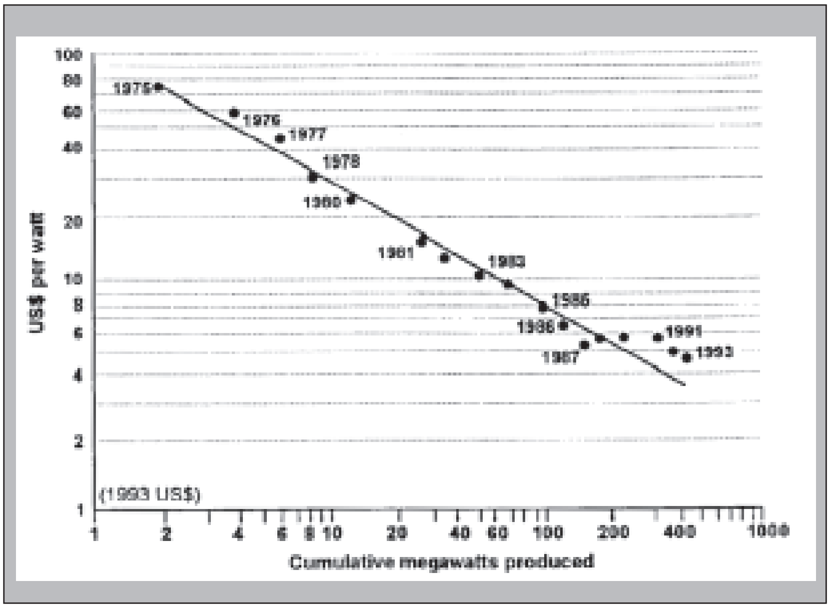


Figure 4
World Nuclear Energy



Source: International Atomic Energy Agency (IAEA), Energy, Electricity and Nuclear Power Estimates for the Period Up to 2010, IAEA, Vienna, Austria (1993).

Figure 5
Penetration Curve for Photovoltaics



Source: Flavin, C. and Lenssen, N. - Power Surge Guide to the Coming Energy Revolution, W W Norton & Co., New York, US (1994)

Figure 6
Evolution of Ethanol Production in Brazil

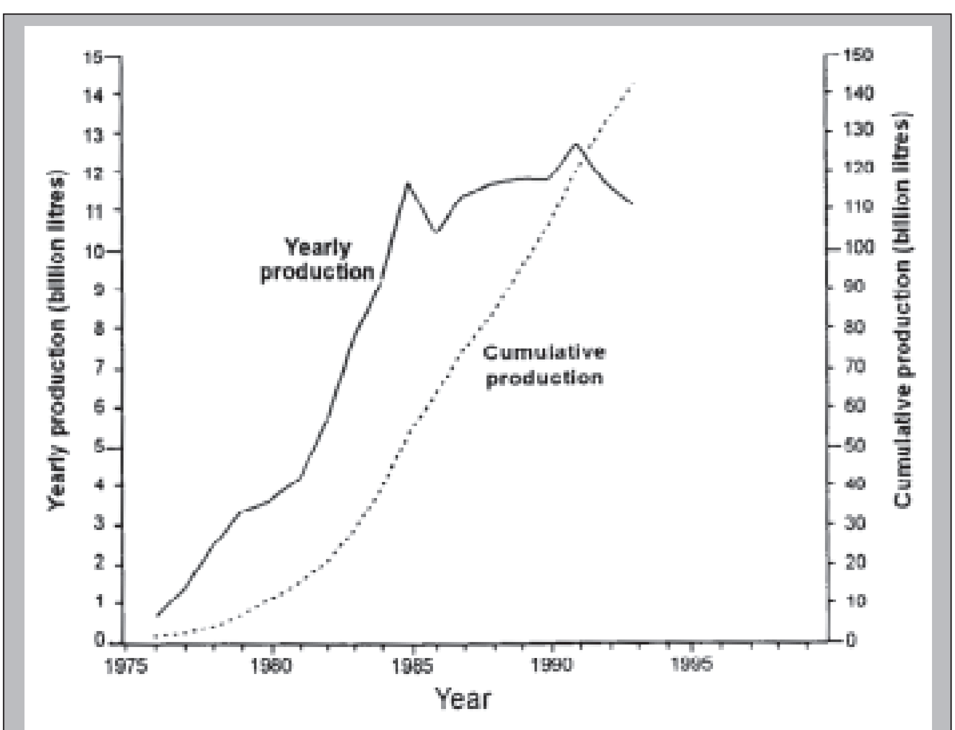
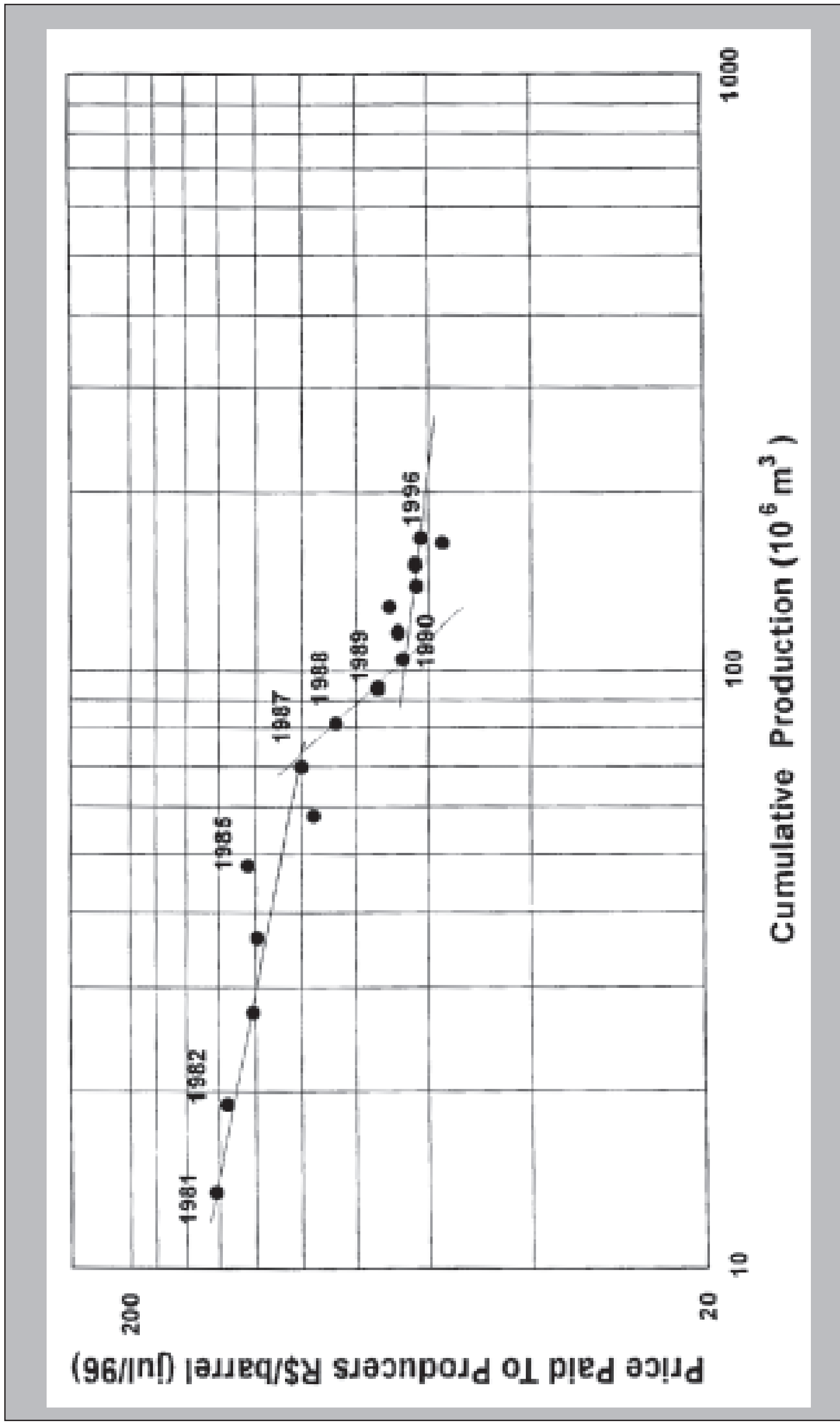


Figure 7

Cost Evaluation of Ethanol in Brazil



Source : Goldemberg, 1996