COMEST Sub-Commission on "The Ethics of Energy"

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Report

TABLE OF CONTENTS

I. INTRODUCTION

1. Sustainable development, meaning the use of our planetary resources for the well-being of all its present and future inhabitants, has become the concept which must guide both individual and collective action at every level and national and international policies. Today, UNESCO is perhaps the United Nations agency which takes best account of this principle in the field of education and culture. One of the major problems confronting all mankind is that of the production and use of the different forms of energy. This is a vital issue for each and every one of us and focusses all the hopes and risks: it lies at the origin of the deep and persistent inequalities between individuals and nations. It conditions the life of present and future generations, while constituting a threat to the environment. The World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) therefore turned its attention from its inception to the ethical problems posed by the production, distribution and use of the different forms of energy.

2. In compliance with the conclusions of the first session of the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) held in Oslo (Norway) in April 1999, the decision was taken to set up Sub-Commissions to enable the members of COMEST to meet in small groups between the statutory sessions in order to work further on the conclusions of the groups of specialized experts. A Sub-Commission on the Ethics of Energy was accordingly created.

3. The reflections at this meeting (see Annex 2 for List of Participants) were based on the work of a group of experts coordinated by Mr Jean Audouze (France), Director of the Palais de la découverte; specialists had an opportunity to share their ideas and experience, while the interest of industrialists was also called to this issue. The report on the "Ethics of Energy" submitted to the Sub-Commission represents the outcome of all this work.

4. Welcoming the members of the Sub-Commission, Her Excellency Mrs Vigdís Finnbogadóttir, Chairperson of COMEST, reminded the audience that the main task of the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST) was to promote values, which will permit better and broader co-operation throughout the world at the scientific and technological and also at the social and cultural levels. Under the terms of its mandate, COMEST has an advisory role to decision-makers in the public and private sectors who have to make choices which must be based on an ethical approach. The Chairperson pointed out that this Sub-Commission, chaired by Professor James Peter Kimmins (Canada), was the third of its kind to be convened; the first Sub-Commission was to consider the ethics of the use of fresh water resources, while the second was dedicated to the ethics of outer space.

She pointed out that the Sub-Commission must define ethical principles, which will be laid before COMEST for its approval at its Second Session (see Programme in Annex 1). In conclusion, she said that one of the goals of COMEST is to stimulate public awareness of the ethical aspects of the application of scientific knowledge and technologies.

5. In his introductory remarks, Mr Kimmins stressed the importance attached by the Sub-Commission to work on the basis of the substantial studies already completed in various fora (World Energy Council and others). He maintained that if the Sub-Commission were to effectively perform its mandate, it must move beyond the strict framework of technical consideration of the issues listed in its programme to examine the ethical challenges involved. Initially, he had felt it appropriate to consider whether the ethics of energy was a problem to be dealt with in isolation, or whether it depended on different aspects of human life to which strictly technical solutions could not provide an answer. In this connection, he referred to questions relating to food, water management and climatic variations, all of which are linked to energy. He said that the definition of ethical behaviour must involve consideration of the space and time factors which are keys to the different approaches to ethics. He suggested that the work of this Sub-Commission should be regarded as an ongoing project which would later be integrated into the work of the other COMEST Sub-Commissions in a global approach to ethical conduct; this might require the definition of a generic mechanism to allow COMEST to apply the method adopted for the ethics of energy to the other problems with which COMEST will have to deal. Any solution to an energy problem will have a social cost, raise ethical problems and influence the solution to other difficulties posed by other human activities. There is practically no aspect of human activity which is not bound up, to some extent, with the cost and availability of energy. Consideration of the ethical aspects of these activities therefore presupposes an analysis of their energy dimension. To define an ethical line of conduct for men and women, the ethics of energy cannot be envisaged without taking account of all the interactions at local, national and global levels.

II. GENERAL DISCUSSION

a. The dilemma of energy demands for development and an ecological conscience in developing nations: a chance for an ethical approach?

6. The presentation by Mr José Sarukhan showed that life on earth is entirely dependent on energy extraction and transformation. These have been at the very heart of the evolutionary process since life first emerged on our planet. Since its origins, mankind has extracted this energy from the natural systems around him, first as a source of food and then, after

the agricultural revolution, by modifying the environment and animal species to cultivate the soil and develop cattle farming. Growing demand for energy, associated with agricultural activity and industrial development, lies at the origin of the environmental changes imposed on the natural systems of our planet. This growth has come at a high cost to the environment with agriculture even described as “the most devastating human activity for the environment of our planet”. However, never before the industrial revolution was human activity capable of changing so profoundly, and on such a vast scale, the ecosystems, landscapes and atmosphere of our planet than in the past 250 years or so. According to recent studies, the rate of extinction of species has been 1,000 times higher this century than before the appearance of mankind. Given the rate of disappearance of habitats, and in the light of observations in the field, it is estimated that nearly 13% of animal or vegetable species of the planet will have disappeared by the year 2015, including a great many in the developing countries. These devastating effects on the ecosystems are compounded by the process of global warming and the constant increase in greenhouse gas volumes. Despite the agreements reached in Kyoto, setting out targets and calendars for the reduction of greenhouse gas emissions, it seems self-evident today that most industrialized countries will not meet these targets. To stabilize the planetary climate, carbon gas emissions will have to be effectively reduced by substituting renewable energy sources for fossil fuels. The main factors contributing to the use of energy are the size of the population and the demand per person, which is normally dependent on economic wealth. These two factors are set to experience rapid growth in most of the developing countries. High levels of energy demand are therefore predictable. Mr Sarukhan stressed the impossibility of predicting sustainable development scenarios which satisfactorily meet the needs of society without a correct assessment of the environmental impact of the different levels and types of energy demand. For this purpose, the countries must not just have appropriate methods but need pertinent information on the sources of energy and energy conversion processes, the features of the end users and, first and foremost, the consequences of the technologies used for the environment. There can be no doubt that renewable energy sources must occupy an increasingly important position, especially for the developing countries if these are to strike a better balance between development and ecological viability. In face of the dramatically unequal distribution of energy and disparities in energy consumption rates, the first priority of sustainable development for decision-makers in every country today is to extend access to energy services to those who are deprived of them at present, primarily in the developing countries. Failing such action, their opportunities for education, health and living conditions will be in jeopardy. For most persons with a Western cultural background, decision-makers and in particular science and technology hold out the sole hope of a solution to environmental problems which often have highly technical dimensions. As science habitually provides objective and factual responses, its help in resolving environmental problems seems self-evident.

7. The need to take account of the interaction between energy distribution and its impact on the environment was highlighted. The link between these two factors was stressed with the population needs often taking priority over the desire to conserve the environment. Here an ethical dilemma exists: how can the short-term social cost, born essentially by the underprivileged developing countries (a cost which is liable in the short-term to widen the disparities between the privileged and deprived, industrialized and developing countries) be balanced against the long-term advantages of evolution towards a more sustainable society which is better able to respect our planetary environment? Economic disparities between the countries are closely bound up with the availability and distribution of energy and the revenue derived from this by national governments. Similarly, economic disparities within a particular country are linked to unequal access to energy and also to the wealth and resources generated by it. Given the importance of the problems posed by the necessary equitable access to energy, it was suggested that the Sub-Commission should deal with the economic aspect of the issue of access to energy resources in parallel with the scientific character of environmental issues. In this context, the problem of the capital infrastructure needed by the developing countries for the implementation of appropriate energy policies arises with the emphasis on renewable energy sources and management of ecological issues. In this regard, the experience of some countries is particularly interesting such as Mexico which is at the frontier between the developing and developed countries. It also seems important to study the relationships existing between cultural behaviour patterns and access to energy or its use and also the issue of social and environmental impact. It would therefore be appropriate to examine the actions which the developing countries might take to develop scenarios for energy use with a view to sustainable development. In this regard, the question arose as to whether sustainable development is an ethical concept. The moral significance of the ethics of sustainable development resides less in the theoretical and sophisticated concerns of experts than in the vision of a new mode of life which is understandable and accessible to all human beings. Lastly, environmental challenges are neither exclusively nor primarily confined to the scientific and technological field. The problems bound up with the environment raise fundamental questions over the price that we, as human beings, accord to our nature and the life which we should lead, our position in nature and the world in which we could develop all our talents. Environmental problems call for answers to questions that are essentially ethical and philosophical in nature.

8. Having regard to the possible role of COMEST, although the Commission must organize its own discussions, it would be desirable for its awareness-creation campaigns to be based on publications which, through the simplicity of their contents and the exemplary nature of the situations evoked, would be as widely accessible as possible. The example of the automotive industry was cited to illustrate the adage that it is better to travel slowly for a long time than to advance at high speed with a high energy cost. Quite apart from the importance of keeping citizens informed, an objective approach by information disseminators is essential. COMEST could develop in parallel actions to educate the public, create an awareness of ethical issues among decision-makers and encourage a pedagogy of mediation. The need to deal with these energy savings from the philosophical angle was also stressed. COMEST might also undertake awareness-creation actions to promote the importance of the duty of energy research. Measured against the considerable expenditure on nuclear energy running at around 6 billion dollars, only one-tenth of that sum is currently set aside for energy research.

b. How to harness hydropower as a renewable form of energy with minimum negative consequences?

9. Mr Daniel B. Botkin, quoting the example of hydropower in the United States of America, pointed out that when the world ecological movement was still in its infancy in the sixties and seventies, this energy source was regarded as clean and good for the environment. The reservoirs created by building dams provided water resources for regions which had always been deprived of them previously. In the early seventies there were many people who envisaged the possibility of building small hydraulic plants in rural zones to reduce the dependency on fossil and nuclear fuels. However, the construction of massive dams often destined primarily for power generation on major river systems has brought major ecological changes. Initially this energy source was felt to respect the environment, because it has no impact on the quality of the air, water and soil. Although the construction of a dam meant that the flow rate of a water course could be controlled to satisfy the need for electricity and stabilize the flow to reduce floods and drought in the nineties, the public became aware of the negative repercussions of hydraulic works on the environment: dams and their reservoirs altered the course of rivers, their banks, marshes and destroyed the habitat of many animal species. Vegetation, ecological cycles, variations in water flow rates and levels, droughts and floods were completely overturned. Hydropower was therefore felt to be prejudicial to the environment because of its green impact, i.e. its implications for life on earth and its diversity. Hydropower plants were also seen as destroying major natural sites and in the late nineties leading ecological movements advocated the elimination of many dams. The image of hydropower

changed from that of an environmentally-friendly energy source (renewable, clean, aesthetic) to that of an energy that was harmful to the environment (because it destroyed natural habitats and ecosystems, threatened or annihilated species, destroyed scenic beauty and disturbed natural variations which are perceived today as ecologically necessary). However, in the developing countries where electricity is at a premium the construction of dams is booming. Many countries plan to build major dams, especially those which lack fossil fuel but are potentially rich in hydropower which they see as necessary to their economic growth. A new question of environmental ethics has now arisen: can hydropower plants be justified? Under what conditions can hydropower be developed while respecting contemporary environmental interests? The decision to build a new hydropower plant invariably entails a series of compromises in which the preservation of ecosystems plays a major role. Similarly, such a decision must be balanced against the possibilities for the use of wind and solar energy (with less negative impact on the environment) and fossil fuels. Another leading principle should be that of seeking a better distributed production at local level, independent from the different sources of energy.

10. This presentation elicited a number of questions from participants, including that of the existence of explicit or hidden subsidies for different forms of energy. It is known that some industrialized countries grant subsidies to developing countries which might therefore build small hydropower units. In the developing countries, the future lies on small plants with easier access to electricity for the rural populations. Subsidiaries might play a key role if existing data were correctly utilized to obtain small-scale equivalences despite the lack of data. Although hydropower is no longer fashionable, it clearly still does have a future if the distribution circuits can be improved and distribution without the use of big grids envisaged. However, the subsidiaries should apply to all forms of energy, especially as it would be desirable to integrate the latter. The relationship between energy use and drinking water needs was highlighted. In this regard, it might be possible to envisage a drinking water royalty which would help to finance hydraulic installations. It would no doubt be possible to absorb the corresponding expenditure in the development costs .The issue of big dams was discussed at great length in terms of their impact on equitable distribution between countries in regard to the use of shared water resources and the environment. The example of the River Niger was quoted. Three major dams have been built on this river, two of them on the territory of the same state. These situations create disparities and raise environmental problems. To build these dams large expanses of land downstream have been drained of their water resources and become unusable for agriculture. The consequences, beneficial or otherwise, observed upstream have negative repercussions

downstream and complicate relations between neighbouring countries. In such situations, relations with hygrometry can also be envisaged: droughts diminish the area of land suitable for cultivation, while usable land increases elsewhere. Under such circumstances, it is therefore difficult to plan agricultural resources. While hydropower is the best way of generating electricity at the environmental level, sound management of the ecosystems is vital. This management must be arranged both upstream and downstream, taking account of generation, distribution and storage (this is a recurrent problem for all types of energy, notably renewable energy sources).

c. How to make renewable energy universally available without negative consequences of the use of energy?

11. In his contribution, Mr Michael Epstein pointed out that every day hundreds of millions of human beings made choices relating to the production of goods or their current consumption. In some situations, energy was a source of profits and income; in others it procured convenience and comfort or quite simply makes life easier. Energy is one of the most important primary commodities for human beings. Its consumption involves the fundamental workings of the economy and society. Today, it is generally accepted that the demand for energy is growing almost everywhere in parallel with economic growth, although this link differs from one sector, country and period to another. Fundamental forces and social policies which have nothing to do with the use of energy influence housing, the industrial fabric, town planning and have a vital bearing on transport infrastructures. These forces vary enormously within a single country and society and their repercussions on energy consumption are far-reaching. There is therefore no universal solution for future energy supply. Every country will have to find its own set of answers. In each country analysts and lawmakers will have to design strategies and programmes to satisfy future demands and requirements. One of the most pressing demands concerns the environmental problem bound up with the generation, transformation, distribution and consumption of energy, with particular reference to fossil fuels whose consumption produces CO_2 emissions. On the subject of energy yields and advanced technologies, Mr Epstein pointed out that the increase in energy prices, especially after the first oil crisis, had brought about a distinct change in energy production and consumption involving both technologies and mindsets. The most important repercussion of this crisis was an increase in energy yields and greater efficiency in power generation. A further repercussion was the further use of coal in traditional power plants. The greater use of coal and natural gas brought the price of electricity down in the last ten years and made power plants less vulnerable to oil price changes, much less so than transport. Moreover,

the interconnection of the national and regional grids and progress in power transmission make electricity less expensive and enable remote areas to be supplied. As to renewable energies, it is certain that these have made substantial progress in recent years and should represent between 30 and 50% of primary energy in 2050: the world market for photovoltaic energy is currently making the transition from off-grid applications which the purchaser regards as economical to applications connected up to the grids. The use of wind energy is growing constantly. Last but not least, solar power plants have not yet entered into commercial operation, but hold out the highest potential of all renewable energies; moreover, they can be used to generate a different form of energy (the example of solar energy which is capable of producing methanol was cited).

12. It has become essential to acknowledge the fact that energy requires precise long-term planning with the assignment of the appropriate resources. All the possible energy choices, including traditional biomass, hydropower and renewable energies, must remain open to improve yields and energy consumption. However, each country must make its own choices and define the percentage of each type of energy which will be used for national production or consumption. This is where ethical reflection comes in to identify good combinations or define new ones. A financial climate which is favourable to renewable energies must be created in the framework of environmental goals. Lastly, investments must be made in research and development and education projects to make ethics a strong component of the energy system in a sustainable perspective.

d. How to provide biomass energy in a sustainable way that minimizes negative environmental and social (including ethical) consequences?

13. Wood is the oldest fuel known to human beings. After pointing out that it has been used as an energy source since the discovery of fire, Mr Paul Fung presented the different ways in which energy can be derived from biomass. The growing world production of wood and coal gives an idea of the importance of exploiting the biomass for energy purposes. Although production, sale and consumption figures are available for sources of energy distributed in grids, the data for the biomass do not always take account of the volume harvested and consumed by individual households, especially in the developing countries. Contrary to coal mines and gas and oil fields which are highly concentrated energy sources, biomass is widely spread over the earth’s surface. While it is well-suited to on site applications or to regional exploitation, its collection, centralization, processing and distribution are expensive. In general, it has a lower energy content in terms of both weight and volume than most fossil fuels.

The useful distance for its use is that over which it can be carried, i.e. a few kilometres, whereas for commercial wood the economical transport distance is around 100 km. Biomass also has a low energy value per unit of weight: 25% of that of oil. Its low density poses a problem in terms of transport and storage although today materials can be produced with a combustion capacity which also enables transport over longer distances to be improved. To the extent that under certain conditions biomass resources can be renewed, the process satisfies the need to meet our present requirements without jeopardizing the satisfaction of the needs of future generations. However, while biomass consumption exceeds its rate of renewal, there is still a deterioration of the environment. Sustainability depends therefore in part on the balance between supply and demand. The different ways of increasing the supply of biomass through rational use of land were explained; use of methods capable of increasing biomass production; higher energy conversion yields to contribute to sustainable energy production; and last but not least, use of biomass residues to generate energy. Mr Fung referred to the role of biomass energy exploitation for the reduction of the environmental impact. When the biomass is used rather than a fossil fuel, greenhouse gas emissions are reduced and accordingly also the risk of climate change. However, the biomass is only a source of renewable energy if it is used in a sustainable matter. Its overexploitation which is ecologically harmful must be avoided because it would lead to deforestation and disappearance of vegetation on a vast scale. In view of the social benefits of biomass energy exploitation, the latter is a simple fuel present in most countries, rich and poor alike. The progress of biomass energy exploitation and the distributed conversion processes can provide rural areas with better forms of energy, such as electrification.

14. In the context of the use of renewable energies, and in particular the use of biomass, the energy efficiency of such processes is becoming an important challenge. Greater efforts must be made to satisfy consumers' wishes, while developing pedagogical programmes. Similarly, the pertinence of the creation of new modes of energy production and the desired sustainability of ecological systems must be envisaged. It sometimes happens that, by wishing to produce biomass, trees (especially the eucalyptus which tend to dry out the ground water) are planted. In addition to the caution which must surround the introduction of new plant species, account must also be taken of socio-cultural considerations: there is a difference between what is used by an individual on the one hand and by society on the other. Before launching any project, a distinction must therefore be made between the values immediately gained by the individual and those acknowledged by the whole population. Lastly, in the developing countries, because of the exodus from the land to urban zones and the resulting exchanges, new priorities are now liable to overturn the

balance in the mode of life existing in the rural world. A new use of time must be considered because new modes of energy production and use are being introduced. To the extent that this is a human problem, an ethical reflection must be conducted to find appropriate answers. Finally, having regard to the ethical aspects of the use of the biomass, the constraint of distance makes it necessary to reserve the biomass for the occupants of the land on which it has developed. The rights of ownership of inhabitants must therefore be protected to promote sustainable production. The fact that the accumulation of greenhouse gases and their impact on global warming or climate change are largely due to the industrialized countries , this is an important factor. While the latter are the main causes of greenhouse gas emissions, they must assume their responsibility for the sustainable development of the developing countries to make sure that these are not constrained to use less expensive but polluting technologies. The industrialized countries should take greater account of the development of renewable energies and help the rural sectors of the poor countries to better exploit the capacity of their ecosystems with a view to sustainable development.

e. How to harness prospects for future energy technologies, and for the equitable distribution of these around the world without the usual accompanying negative impacts?

15. Mr Ayodele A. Esan pointed out that the foremost concern for the development and use of energy was economic in nature. With the progress of conversion technologies and devices for final use, education has gradually been imposed as an additional factor. After the Rio Summit, the environment and, more recently, the concept of sustainability had been added. Mr Esan also emphasized the importance measured against energy problems of population forecasts which suggest that the world population will reach 8.4 billion in 2030. He highlighted the importance of the rural population, which currently accounts for more than 70% of the population of the developing countries and lacks the energy to cover its basic needs. In the developing countries, the rural population has always depended primarily on traditional energy sources. It is only recently that technological progress has permitted a gradual transition to modern (commercially available) energy types such as kerosene, diesel and electricity. One of the main requirements is to satisfy human needs. According to a recent study, 7% of world electricity generation would be enough to satisfy fundamental human needs. Electricity is in fact the key to the modern world. Having regard to the growth of economic productivity, it appears that traditional energy technologies are inefficient and have drawbacks from the angle of natural resources, health and society. In the past, attention together with investments and actions focussed primarily on urban areas. The products destined for the rural areas were of lower technological value and of little

commercial value. Technological and institutional challenges must therefore be taken up (charging, collection of bills) to ensure that the energy needs of the rural populations are satisfied. Equitable distribution must take account of the comparison between supply and demand. In this regard, it must be acknowledged that the level of income is a major factor which influences energy consumption. A gradual transition to modern energy systems is preferred with more effective provisions for final use. The transition to more efficient modern systems represents an initial cost; hence the need for plans for the allocation of modest credits to the rural environments and suitable fiscal measures.

16. In general, the adoption of a technology depends on the availability of technical resources, access to necessary financing, accessibility of information on decision-making for planners and local communities, participation of the population etc. For this purpose various measures have been cited. To be sustainable, development must be accepted by the population itself: rural development must be integrated and associated with other measures for agricultural, educational, infrastructural, social and political factors. The creation of regional expert centres will facilitate this involvement of consumers. Financing, education and training, the dissemination of information, local participation and cultural issues will therefore be among the delicate and crucial challenges to be taken up in future.

f. Strengths and weaknesses of each type of energy

17. Introducing his presentation, Mr Jean Audouze pointed out that the life of six billion human beings depends on access to the different types of energy, even if nearly two billion of them still only use those provided by burning heating wood. Moreover access to energy resources is extremely uneven, since 20% of mankind (the industrialized counties) consume 60% of the available energy, leaving the remaining 40% to the other developing countries or those in a state of transition. Some trends have a severe impact on the pressure which will be exerted on the different energy sources: the anticipated global population growth; the growth of urban areas leading to higher energy pressure and the relative growth in the number of inhabitants who have not yet achieved self-sufficiency in energy as compared to those who have reached this stage. In this regard, the principle of equity stipulates that man, regardless of his geographical origins and social status, must have access to energy. To the extent that an increase of this type of consumption is desirable, this will be one component of the pressure on energy resources. There is no reason why demand should fall and failure to satisfy this demand would be immoral, considering that throughout the 20th century we tolerated the wastage of this resource by the developed countries. Moreover, an objective analysis of the different energy sources (fossil, nuclear and renewable) shows that

each of them has manifest weaknesses. Fossil energies have the merit of being very easy to use (they are particularly appropriate for heating and transport applications) and of being abundantly available and therefore relatively cheap for several decades to come. But many difficulties surround their use in the 21st century. The first is bound up of course with the accompanying greenhouse gas emissions. Application of the precautionary principle seems necessary in this instance and justifies the adoption of international protocols. Moreover, the world economies are particularly sensitive to the price of oil (and gas) so that management of this resource is becoming an absolute necessity which should not be left to the sole responsibility of the producer countries and distributing companies. In the field of nuclear energy, the three major difficulties encountered in the implementation of this energy source are well known: first of all the acceptability to the public of the peaceful use of this form of energy, rigorous safety requirements and lastly the difficult matter of the management of waste. While it would be desirable to see the renewable energies (hydropower, wind, photovoltaic, solar, thermal energy and bio fuel…) progress in every respect, in terms of both quality and quantity, their use must be accompanied by sound management of the environment (involving the conservation and equitable use of agricultural land); moreover, the cost per unit of energy remains high.

18. In the exercise of its mandate, COMEST could focus its recommendations on an effort to control energy consumption; promotion of the duty to engage in research and an effort of objectivity and impartiality on the part of the citizens, decision-makers, pressure groups and media. An ethical recommendation might finally concern the need to assure the most complete and objective access possible to all information about such sensitive subjects which hold the key to the future of a large part of mankind in this twenty-first century.

III. Background for Recommendations

a. Decision-making and action based on ethics

19. Ethical reflection in the field of energy can highlight basic principles, enabling interested countries, communities and individuals to appraise the implications of energy-related decisions and action. This needs to take into account not only the perspective of present generations, but also environmental considerations and the standpoint of future generations. Such principles imply to consider critically cultural values, norms, expectations and behaviours when these affect negatively one or more of these three aspects.

i. Such an ethical reflection is necessary in the development of energy policies of all nations. In this regard, UNESCO could facilitate access to recent and accurate knowledge concerning the technical and ethical aspects of the production of energy, in order to meet present needs and expectations. It must also encourage critical assessment of benefits and costs of alternative means of satisfying energy demands, and their impact of the environment both short- and long-term as well as their implications for present and future generations.

ii. Such a critical analysis should be undertaken in conformity with the responsibilities implied in the 1987 Brundtland Report *Our Common Future*: that the requirements of the present generation are met without leaving environmental debts to future generations. This would have an impact on the whole society: from choices and behaviour of individuals to policy decisions, from investment strategies to Research and Development priorities in the public and private sectors.

iii. COMEST is called upon to define principles which can provide decision-makers with criteria, other than those strictly economical, for making choices, although one should not overlook neither economic considerations nor other constraints. The ethical role of COMEST is indeed intended to set the limits between what is possible and what is acceptable, and to be the keystone of a new culture of responsibility and solidarity. Thus in carrying out this task, the COMEST Sub-Commission on the Ethics of Energy recognized the importance of co-operation with international entities (e.g. World Energy Council, IASA), which have already made useful contributions in their own fields of technical, financial and economic expertise.

iv. The ethical considerations, recommendations and principles formulated in this document stem from a coalescence of the various opinions expressed by the experts of the COMEST Sub-Commission on the Ethics of Energy. The proposed conceptual framework strives to suggest priority actions plans so as to raise awareness and lead to informed and responsible decision-making.

b. Ethical considerations

20. Human societies have always relied on external energy supplies to fulfil their development needs, but today present societies have become not only totally dependent upon energy, but also severely addicted to its ever-increasing utilization. The fulfilment of expectations and aspirations of people are closely related to their access to energy. As a result, inequalities in access to affordable energy, both within and between countries, have become closely associated with inequalities in environmental security and standards of living. The preservation of the environment is a key condition for the perpetuation and prosperity of human life. If this environment is to

continue to provide what is needed for sustaining and developing the human species, it is imperative to fully understand the importance of preserving and improving its ecological functions at local, regional and global levels.

21. Over the last decade, the negative effects of energy production and consumption on the biosphere have become evident even to the general public. More and more people are now becoming aware of the impact of human activity on the local, regional and global ecosystem, and of the urgent need to safeguard the environment in order to guarantee the well-being of people and the existence of future generations. Such an ethical approach to energy is today obvious, taking into account two additional dimensions: the environment and future generations.

22. As both the human population and the *per capita* demand for energy continue to increase, the global energetic need will also steadily expand. Over the past 40 years, the doubling of the world population (an increase of three billion), together with a 50% increase in the average energy demand per person, have resulted in a 300% increase in global energy consumption. Over the next 40 years, a further increase in world energy demand is predicted between 50 to 225% (World Energy Council). As the world energy consumption and demand continue to increase, the ways in which this demand is satisfied should be modified, whenever possible, to avoid negative consequences. The *Principle of Sustainable Development*, as defined by the Brundtland Report, implies that the present consumption of energy be examined in the light of the foreseeable needs of future generations. Meeting energy demands of present generations, as envisaged today, unquestionably influences the ability of the environment to sustain the needs and expectations of future generations, and their access to energy sources in the future. Consequently, it is both disappointing and alarming to note that, eight years after the 1992 Rio de Janeiro Earth Summit, little substantive progress has been made on issues fundamental to human safety, environmental quality and the future of humanity. Perhaps the most tangible indication of this neglect is the increasing global climate change (global warming) largely associated with the release of gases generating greenhouse effects as a consequence of unrestrained and dysfunctional energy production and consumption. UNESCO action in this field would be an important tool to assist the process of implementation of the United Nations Framework Convention on Climate Change (UNFCCC).

23. Many ethical issues stem from inequitable access to energy and the environmental consequences of different ways of meeting energy demands. The impact on future generations of the present generation's energy consumption is an issue that needs to be effectively addressed. A careful evaluation of the implications of such energy consumption with regard to environmental considerations also needs to be carried out.

24. The following issues need to be addressed in order to draw up an appropriate framework for evaluating the ethical aspects of energy.

a. What would be an ethical approach regarding access to energy?

This question requires a definition of the rights of individuals and nations of access to energy, as well as a definition of the equitable distribution of energy between nations as well as within individuals.

b. What would be an ethical approach to the production of energy?

This question requires a balanced approach to the issue of renewable and non-renewable energy sources, as well as the inclusion of full costing of energy production and distribution, taking into account subsidies and external costs, as well as environmental and social costs.

c. What would be an ethical approach regarding environmental implications?

This question requires an assessment of the impact of energy policies on the environment, as well as a consideration of energy consumption and its implications for other species.

d. What would be an ethical approach regarding obligations to future generations?

This question requires an evaluation of the degree to which current energy choices should be conditioned by considerations of their implications for future generations.

25. These questions need a thorough analysis of the ethical dimensions of energy policy. Such an analysis should define the conditions, on the one hand, of equitable access to energy and environmental protection, and on the other, of the definition of duties and exercise of rights of individuals and nations.

c. Risks of energy production and use: short- and long-term consequences and tradeoffs of alternative energy strategies

26. In formulating principles and recommendations in the field of the ethics of energy, risks which are linked to the production and consumption of all energy sources cannot be overlooked; indeed, they entail a series of foreseeable and unforeseeable dangers.

27. Fossil fuels, at present the predominant energy source, pose the greatest long-term global environmental risk due to the carbonization of the atmosphere, its impact on global climate changes, and subsequent risk of extreme weather conditions. They are also a finite resource. Nuclear power is another major energy source in some developed countries, but the problem of long-term storage of long-lived radioactive by-products has not yet been resolved. Safety of nuclear reactors and proliferation of nuclear

weapons are other factors of concern. Renewable energy presents the advantage of being perpetually available but has its own set of risks. Waterpower poses risks to fish, flora and fauna through the diversion of natural water flows. Dams result in loss of land, and dams can jeopardize human safety. Wind is subject to weather conditions thereby producing variable and hazardous power supplies. Wind turbines can cause noise and visual pollution, affecting the aesthetics of the landscape. Solar power is subject to the availability of sunlight due to the diurnal factor and cloud cover. It also requires energy storage in batteries, which are a significant cost factor. Moreover, solar collectors need to be extensive to provide the necessary capacity, thereby also affecting the visual aesthetics of the environment. Biomass requires a sustainable supply or else it would add to gas emissions which increase greenhouse effect. Establishment of large-scale supply plantations could impact on land-use considerations and bio-diversity issues. Poor burning practices can cause smoke pollution. Other renewable energy resources, namely geothermal, wave and tidal power also have their own risk factors, which need to be assessed.

28. While ideally it would be desirable to have risk-free energy sources, which could meet the energy needs of humanity, to the best of present knowledge, there is today no energy source totally free of drawbacks.

29. Scientific research should aim at:

- innovative uses of low-cost, high-efficiency fossil fuels, while preventing CO_2 dispersion in the atmosphere;
- waste-reduced or waste-free nuclear fission and harnessing nuclear fusion, which has a full potential fuel supply and promises for a cleaner energy;
- lower cost technologies for renewable energies with minimal pollution of all kinds (e.g. damage to landscape).

30. As a result of the above, the Sub-Commission on the Ethics of Energy proposes to COMEST's consideration the following principles and recommendations.

IV. PRINCIPLES AND RECOMMENDATIONS

1. Equitable accessibility

Energy should be available to individuals on an equitable basis and at an adequate level, allowing them to meet their needs, while not impairing the environment or jeopardizing rights of others, in the present or the future.

2. Conservation of energy

Reduction of energy consumption, through reduced energy waste, should be a major focus of energy policies. Moreover, efficient use of energy should be pursued to reduce overall demand. Pricing measures are one way to discourage excessive use of energy due to lifestyle preferences.

3. Precaution and reality

While ideally the use of potentially dangerous energy sources should be limited or avoided, there is factual evidence that today no energy source is totally free of drawbacks. It would indeed be desirable to have risk-free energy sources, which could fully meet the energy needs of humanity. However, this is not yet the case although scientific research continues to work in this direction.

4. Research priorities

The highest priority should be given to scientific research geared towards risk-free and pollution-free fossil fuels and renewable energies, waste-free nuclear fission and, eventually, safe nuclear fusion under the same conditions. This would produce an effective mix of environmentally benign energy sources for the present and future generations.

5. Innovation and adaptation

In order to meet the needs of their people and economies, all countries should invest in research, development and capacity-building in the energy field. All potential sources of sustainable energy should be examined without *a priori* prejudice and their costs and benefits including environmental and social should be objectively evaluated.

6. Sustainability and intergenerational equity

Energy sources should be sustainable, thus equitably meeting the needs of the present without impairing the ability of future generations to meet their own foreseeable needs. In this regard, energy sources should ideally be risk- and pollution-free and available in perpetuity.

7. Environmental responsibility

Active measures should be taken to reduce the environmental impact of energy production and use. This involves reductions in the negative environmental consequences of energy exploration, production, storage and distribution. In the short run, particular emphasis should be put on:

- the establishment of an effective global framework to limit the release of gases into the atmosphere, inducing the greenhouse effect, in recognition of the dangers associated with global warming;
- the problem of storage of nuclear waste products;
- the environmental impact of unmanaged and unsustainable biomass energy use.

8. Leadership and flexibility

National and international decision and policy makers have the responsibility to demonstrate leadership in the transition to sustainable, affordable and environmentally acceptable energy policies, and not merely to react to energy crises. National energy policies should be as flexible and adaptable as possible, so as to accelerate the transition to environmentally benign and sustainable energy, when new knowledge and technologies improving energy efficiency and sustainability become available.

9. Full cost accounting

The price of energy should reflect its full and true cost, including the cost of infrastructure and delivery, the investments in developing the energy source and the cost of externalities. Government subsidies should not distort the relative price and environmental advantages of different energy sources. However, the need for energy subsidies of various sorts for the poor and for developing nations should be recognized in the short-term. The price of energy should also consider the values and environmental services impaired or removed by the energy source in question.

10. Forecasting

A mindful evaluation of the social and environmental costs and benefits is required by any change in the balance of energy sources, the rate of energy use, and the financial framework for energy. This should be done before changes are instituted, to ensure, as a result, the best possible balance of social and environmental costs and benefits. The implications of any change concerning energy policy for all sectors of the economy and for the environment should be thoroughly evaluated before being adopted. Nevertheless, this attitude should not be used as a pretext for avoiding decisions or action.

11. Media pedagogy and education of the public

Evaluation, public debate, education, information and communication concerning energy should be based on the best and most up-to-date information from authoritative and reviewed sources. In order to facilitate informed choices, information on energy should avoid bias from inaccurate data, preconceived and unsupported positions and fairly and objectively represent the relative costs and benefits of the different energy sources. Information concerning energy should be impartial, accurate and understandable by all.

12. Geographical, cultural and economic diversity

Energy use is an issue that has global implications. All countries have responsibilities for the global and local consequences of their national energy policies. However, existing ecological, cultural and economic differences between countries entail that, while these recommendations are general and thus have global applicability, variations between countries and within countries can be expected over time.

13. Operational necessity

Adequate regulatory and economic means should be identified in order to translate these principles into operational policies and concrete actions.

ANNEXES

PROGRAMME

Thursday 2 November

10:00 a.m. - 10:15 a.m.	Opening of the meeting
10:15 a.m. - 11:00 a.m.	The Ethics of Energy – Introductory remarks *led by: Mr Hamish KIMMINS*
11:00 a.m. - 11:30 a.m.	Break
11:30 a.m. - 12:15 noon	The dilemma of energy demands for development and an ecological conscience in developing nations: a chance for an ethical approach? *led by: Mr José SARUKHAN*
12:15 noon - 1:00 p.m.	How to harness hydropower as a renewable form of energy with minimum negative consequences ? *led by: Mr Daniel BOTKIN*
1:00 p.m. - 3:00 p.m.	Break
3:00 p.m. - 3:45 p.m.	How to make renewable energy universally available without negative consequences of the use of energy? *led by: Mr Michael EPSTEIN*
3:45 p.m. - 4:30 p.m.	How to provide biomass energy in a sustainable way that minimizes negative environmental and social (including ethical) consequences? *led by: Mr Paul FUNG*
4:30 p.m. - 5:00 p.m.	Break
5:00 p.m. - 5:45 p.m.	How to harness prospects for future energy technologies, and for the equitable distribution of these around the world without the usual accompanying negative impacts? *led by: Mr Ayodele A. ESAN*

Friday 3 November

10:00 a.m. - 10:45 a.m.	Strengths and weaknesses of each type of energy *led by: Mr Jean AUDOUZE*
10:45 a.m. - 11:15 a.m.	Synthesis of debates by the Rapporteur
11:15 a.m. - 11:30 a.m.	Break
11:30 a.m. - 1:00 p.m.	Proposals of draft recommendations that COMEST will examine at its 2nd Session
1:00 p.m. - 3:00 p.m.	Break
3:00 p.m. - 4:30 p.m.	Approval of the draft recommendations
4:30 p.m. - 5:00 p.m.	Break
5:00 p.m. - 6:00 p.m.	Closure of the meeting

Annex 2

LIST OF PARTICIPANTS

I. SUB-COMMISSION MEMBERS

H. E. Mrs Vigdís FINNBOGADOTTIR
President, Republic of Iceland, 1980-1996
Chairperson of the World Commission on the Ethics of Scientific Knowledge and Technology (COMEST)

Mr James Peter KIMMINS (Canada)
Member of COMEST
Chairperson of the COMEST Sub-Commission on "The Ethics of Energy"
Professor of Forest Ecology at the University of British Columbia

Mr Jean AUDOUZE (France)
Rapporteur
Director of the *"Palais de la découverte"*

Mr Daniel BOTKIN (United States of America)
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Mr Michael EPSTEIN (Israel)
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Mr Ayodele A. ESAN (Nigeria)
Secretary-General of the Energy Commission of Nigeria

Mr Paul FUNG (Australia)
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Mr José SARUKHAN (Mexico)
Member of COMEST
Personal Adviser to the President of the Republic of Mexico
Former Rector of the National Autonomous University of Mexico (UNAM)
Senior Professor at the Institute of Ecology, UNAM
Member of the American Academy of Sciences
President of DIVERSITAS

II. UNESCO

Mr Georges B. Kutukdjian
Executive Secretary of COMEST
Director
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and the Ethics of Science and Technology

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Mrs Nicole Lorin
Division of Human Sciences, Philosophy
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CONTRIBUTIONS

STRENGTHS AND WEAKNESSES OF THE DIFFERENT SOURCES OF ENERGY SUPPLY

by Mr Jean AUDOUZE (France)
Director of Research at the CNRS (Astrophysics)
Director of the Palais de la découverte
Co-ordinator of the COMEST Working Group on the Ethics of Energy

The lives of six billion human beings depend today on access to the different sources of energy (fossil fuels, nuclear and renewable power), even if almost two billion of them still only use energy obtained by burning wood. As the contributions to this meeting aptly point out, access to energy resources is extremely uneven: 20% of mankind (the OECD countries) use 60% of all available energy, leaving the remaining 40% to the countries which are either developing or in transition.

Three main trends will significantly influence the demand placed on the different sources of energy in future:

- The first is of course the overall increase in the world population, which may rapidly reach ten billion human beings by around the year 2020: at the 2050-2100 horizon, this number might be as high as 12 to 15 billion. However, the rate of world population growth is falling sharply, no doubt because of the policies pursued in more and more countries to "control" the birth rate. This phenomenon may result in a downward revision of the population forecasts. Some projections even go so far as to conclude that the world population will not exceed 8 billion persons by the end of this century. This factor must be stressed, as it may have a considerable influence on all aspects of the ethics of energy.

- The second is the increasing trend towards urban development. In 1900, only 14% of the world's population lived in towns. By 2020, this number will exceed 62%, half of them in towns with more than one million inhabitants. This effect too will result in an increase in the "pressure on energy" because the rapid spread of urban development is accompanied by an intensification of infrastructures and transport demand, which both make the "energy factor" still harder to deal with.

- The third trend is a relative increase in the number of inhabitants who have not yet achieved an adequate level of energy supplies, as distinct from those who have done so. The principle of equity stipulates that all persons, regardless of their geographical origins and social status, must have access to energy. It would therefore be desirable for this type of consumption to increase rapidly. This possibly new component of energy pressure is both legitimate and inevitable.

We therefore find ourselves confronted with a somewhat critical energy supply situation, because there is no reason why demand should fall and it would be immoral not to satisfy that demand after tolerating in the 20^{th} century wastage of this resource by the developed countries - especially by the two great blocks which dominated the history of that period, the United States of America and the former USSR. Recent evidence of a justified rise in oil prices gives the lie to certain optimistic comments made in Oslo (see the presentation by Mr G. Aslanian, Proceedings of the First Session, page 67). While we would all like to see a fall in energy intensity (i.e. the consumption of energy per unit of GDP), that necessary development cannot be painless. In this contribution, we will go on to consider some ways and means of moving towards that goal.

We are living today in a world which can no longer do without energy, so much so that some people are calling for a declaration of the universal “right to energy”. The facts that we outlined above prove that demand for energy is bound to grow. At the same time, an objective analysis of the different sources of energy (“fossil fuels”, “nuclear” and “renewable” energy) demonstrates that each of them has incontrovertible weaknesses to which attention must be drawn:

I. **Fossil fuels** have the merit of being very easy to use (they are particularly suitable for heating and transport applications) and will remain abundant for a few more decades and therefore relatively cheap; however, their use will pose many difficulties as the 21st century advances. The first problem is, of course, bound up with the accompanying emissions of greenhouse gases (carbon dioxide and methane). Many climatologists agree that the warming of the earth’s atmosphere brought about by the increased presence of these gases in the air is no longer a mere hypothesis, but already a reality. Some see this phenomenon as the cause of more frequent storms and other meteorological extremes. In our view, application of the “precautionary principle” is imperative here and justifies the adoption of documents such as the Tokyo Protocols, which most of the signatory countries will unfortunately have great difficulty in respecting. Particular attention should be given to the prevention of accidents such as the sinking of the Erika (oils spills) or leakage from gas pipelines of the kind that are unfortunately being reported at present. Moreover, the world economies are particularly sensitive to the price of oil (and gas), as recent events prove. Sound management of this resource is therefore becoming imperative and cannot be left to the sole responsibility of the producer countries and distributing companies.

II. As to **Nuclear energy**, the three major difficulties encountered in its use are well known: firstly the acceptability by the public of the peaceful use of this source of energy. Secondly, the use of nuclear energy imposes particularly drastic security criteria. We cannot be too cautious in the implementation of these techniques which require particularly well-trained personnel and compliance with draconian procedures. Of course, the major concern resides in the disposal of the final waste products. Despite the difficulties posed by this fuel, we are convinced that the experts (researchers, engineers and technicians) who are working on a solution to this problem will succeed in overcoming these difficulties reasonably soon. We remain concerned by the way in which the subject is approached in the media and by persons responsible for informing and communicating with the general public. From that angle, the “signals” sent out by certain governments, such as that of the Federal Republic of Germany, are hardly likely to facilitate the sound use of this energy source which remains unavoidable, as we shall seek to demonstrate below.

III. There is a unanimous wish for **Renewable energy sources** to be increasingly used and enhanced in terms of both quality and quantity. These energies cover all kinds of different processes (hydro-electricity; wind energy, photovoltaic, solar and thermal energy; bio fuels). These disparate processes seem to share two common features. The first is that, contrary to the hopes of some energy experts who advocate the sustained development of this source, they have little or no impact on the environment (except perhaps for photovoltaic generation). This is particularly true for hydro-electricity, dams and wind energy with noisy generators. At all events, renewable energies are likely to “confiscate” for their sole use extensive sites and landscapes, which we would like to be preserved for other purposes. Moreover, the cost per unit of energy remains high. This constraint is particularly important in the case of photovoltaic energy; we would nevertheless wish to see this type of energy developed vigorously to supply suitable quantities of energy to populations scattered over extensive territories.

That being so, the routes which COMEST must urge the governments and industrial and economic leaders to follow are rather narrow.

- The first recommendation is to make a genuine effort to bring energy consumption under control. Recent events prove the preference of governments for economic or fiscal responses to pricing problems. Appeals to save energy remain far too modest, although the opportunities to do so are substantial because they mostly concern the developed countries which can, without major disadvantages, make appropriate efforts to improve the energy yield of vehicles of all kinds, provide thermal insulation for buildings or enhance the energy quality of their infrastructures. Research can and must be encouraged in this direction. The political authorities, educational circles and the media should encourage awareness-creation campaigns for citizens to promote energy saving and the controlled use of energy.

- Energy is as crucial as health to the survival of the species; fundamental and applied research must therefore be encouraged and sustained at a much higher level than we have seen for many years. Research policies pursued by the governments and major industrial groups must facilitate efforts in this fundamental direction.
- In the field of energy, perhaps more than in any other, an effort of objectivity and impartiality must be made by all citizens, including decision-makers, pressure groups etc.

To confine ourselves to just a few examples, the role of the transport of goods by road as opposed to combined rail and road transport, must be examined. Is it really imperative to levy lower tax on the use of diesel rather than petrol in motor vehicle engines? The use of oil and coal products for electricity generation could be prohibited when other means of generation are available. Finally, the attacks currently launched against nuclear energy in some quarters do not always have an objective basis: the risks inherent in this energy source are incomparably lower than those associated with other kinds of power generation. It is now a proven fact that renewable energies will not be able to replace fossil fuels if the use of the latter has to be limited. Therefore, if "energy sufficiency" is to be maintained worldwide on the horizon of the year 2050, allowing for both population growth and rising global demand, the use of nuclear energy is inevitable. A responsible attitude would be to seek rapid, practical and incontrovertible solutions to the three problems posed by nuclear power generation (safety, waste products and acceptability), instead of opposing it out of hand.

Lastly, an ethical recommendation by COMEST might concern the need to provide the most comprehensive and objective access possible to all kinds of information about these highly "sensitive" subjects. After all, they will largely determine the future of mankind in the twenty-first century.

HOW TO HARNESS HYDROPOWER AS A RENEWABLE FORM OF ENERGY WITH MINIMUM NEGATIVE CONSEQUENCES ?

by Mr Daniel B. BOTKIN (United States of America)
Professor of Forest Ecology
at the University of California, Santa Barbara

When the modern environmental movement was young, in the 1960s and 1970s, hydropower was considered clean and environmentally good. It was renewable, did not add toxic chemical pollutants to the environment, had a long history associated with landscape-pleasing old-fashioned watermills, and was common in European history. The reservoirs created by hydropower dams provided recreational benefits, adding lakes to regions where they had not existed. The first major exurban water supply for New York City, Croton Reservoir, first built in the 1840s and enlarged with an elegant hand-built granite dam with a beautiful spillway, created twenty miles of lakes. The park in front of the dam and the reservoir-lakes became recreational destinations, and were considered objects of landscape beauty. In fact, this dam and reservoir are still viewed in this way. When I first started working in ecology, several of us in the faculty of Yale University in the early 1970s discussed how we might create small local hydropower facilities in the countryside to reduce the dependence of the United States on fossil fuel generators and nuclear power generators.

However, the development of extensive dams, for which waterpower was one of the benefits, often the primary benefit, on major river systems in the United States, led to major ecological changes. Recently, the most notorious of these dams are the six major dams on the Missouri River and the major dams on the Columbia and Snake Rivers in Oregon. These dams were built to provide electric power, water for irrigation, to control river flood for the benefit of navigation and the control of floods and droughts. In the first stage in the development of hydropower, this source of power was seen as environmentally good because it did not negatively impact the “brown” issues – the non-biological environmental issues – air, water, and soil quality.

In the 1990s a new recognition of the negative effects of hydropower facilities became evident to the public: the dams and their reservoirs led to major changes in stream, river, riparian, and wetland habitats, destroying habitat for many species of fish, birds, and mammals. The natural vegetation of a region, the natural ecological successional processes, and the natural variations in water speed and level, droughts and floods, were greatly affected. The dams became impediments to migration fish, and even with the introduction of fish ladders, there was a concern that fish mortality increased greatly.

The creation of dams meant that the rate of flow of a river could be controlled to meet the demands of power generation and to stabilize the flow, with a goal of reducing floods and droughts. But the animals and plants in and along rivers were adapted to these variations, and many could not persist without them. The major reservoirs created entirely novel habitats, and were often rapidly occupied by exotic species of fish, eliminating or greatly reducing native species of fish. The complex channels of rivers that had existed prior to the development of the major dams were largely eliminated, so that backwaters, wetlands, and the natural pattern of ripples and pools in streams were often eliminated. Their elimination destroyed habitat for fish, vegetation and wildlife. In North America, the most notorious effects of major dams has been the concern with Pacific salmon of the Northwest of North America. In the 1990s, hydropower facilities were seen therefore as environmental negatives because of their effects on the “green” issues – issues concerning life on the Earth, its diversity and productivity. They were also perceived as destroyed great natural scenery, as with the Glen Canyon dam on the Colorado River, and the Ryan dam, which flooded the famous five waterfalls on the upper Missouri River.

In the late 1990s, a widespread environmental movement developed whose goal was the elimination of many dams. Organizations such as the US non-profit American Rivers, made this one of their primary goals. A landmark event occurred in 1999 at Augusta, Maine, with the removal of Edwards dam on the Kennebec River, the first time that a major hydropower dam was removed in the United States of America. The dam had been in place for more than 160 years, and was present when Henry David Thoreau canoed on the Kennebec and its tributaries during his travels in the Maine Woods in the 1840s. The dam, once a major source of power for a vigorous set of industries in Augusta, no longer served that purpose. The water-power dependent industries had mostly moved away, where labor costs were lower, and the electric power grid made electricity from other sources readily available. Meanwhile, the dam had aged and the river had deposited sediment behind it. The dam posed a legal liability – if it failed, the privately owned dam might subject the owners to litigation for damages. Species of fish, such as shad, which used to migrate and spawn up the river, had not had access to it for more than a century.

The breaching of this dam was a significant media event within the United States. It is the forerunner of removals of other dams. Many of the smaller dams have become environmental, human, and legal liabilities. For example, one dam, on the Ventura River in California, has cracks in the cement structure and its reservoir is heavily filled with sediment, so that the dam can hold only 5,000 acre feet. If the dam ever gave way, the result would be a major disaster downstream, with legal implications for the damage to human life, property, and to natural ecosystems. The recognition that many older dams pose liabilities has added to the societal pressure for dam removal.

So, within the last ten years, the perception of hydropower has gone from an environmental good (renewable, clean, leading to an aesthetically pleasing landscape) to an environmental bad (destroying native habitats and ecosystems, extinguishing or threatening species, eliminating beautiful landscapes, preventing natural variations which are now viewed as an environmental good rather than a social evil).

Meanwhile, in the developing nations where there is a lack of available electric power, the development of dams is proceeding rapidly. Most well-known, perhaps, is the Three Gorges dam in China, but other major dams are planned for many nations, from Laos to Bhutan. Nations lacking in fossil fuels but having abundant potential water power, see the development of this power as necessary to economic development. So, a new environmental ethical question has arisen: are hydropower dams ever justified? Under what conditions could hydropower be developed so that contemporary environmental interests were met?

We can set down broad themes concerning the ways to determine how to make a hydropower dam that is environmentally benign, and in what situations such dams could be developed. However, significant unresolved issues remain that will require research and monitoring, which should be incorporated into the development of new hydropower facilities.

The decision whether to build new hydropower facilities will invariably involve a consideration of tradeoffs. Ideally, a new hydropower facility should only be built if the following requirements can be met:

- The ecosystems, habitats, and species are replicated in sufficient number so that the alteration of ecosystems and habitats caused by the new facility does not lead to an added risk to threatened or endangered species, ecosystems or habitats.
- Preferably, the dam and its reservoir will be built in an area that already has wetlands and ample riparian habitats, enough of which will remain, and so that the addition of the reservoir creates a habitat similar to what already exists.
- The geology, climate, and vegetation of the watersheds result in low sedimentation rates so that the dam has a long lifetime, and therefore rapid development of sediment behind the dam does not become a major disposal problem (often the transportation and redeposition of such sediments cause environmental damage).

- There is an adequate baseline set of information about the species, ecosystems, and habitats so that changes in these can be tracked over time.
- In addition, similar adequate baselines exist for similar watersheds that are not to be modified, so that comparisons can be made in the future regarding species, ecosystem, and habitat change (all these change naturally over time, so that the way to track effects of the hydropower facility itself it by comparison with other watersheds.
- A monitoring program involving the watershed to be modified and comparison watersheds is put into place prior to the closure of the dam.
- Adequate attention be paid for fish passage, for counting and monitoring fish, for providing backwater habitats and variations in waterflow that accommodate the needs of native species.
- The dam and reservoir do not destroy unique landscape beauty.
- An evaluation is made about the benefits to be received from the dam versus present land use of the region.

The existence of a dam and hydropower facility means that water flow can be controlled. In the past, the control has focused primarily on attempts to meet variations in power demands (peak demands) and to reduce flooding and drought effects. However, the ability to control the flow can also be used to provide the kinds of seasonal and annual variation in water flow that is natural to the area and to which animals and plants have evolved and adapted. For example, in a hot year, cold water from released from the bottom of a dam could benefit certain fish species. Species that require changes in water level to complete their life cycle could have these requirements met by control of the flow.

To allow for these uses of flow control, estimates of power generation from a hydropower facility must be modified downward to give realistic power outputs consistent with the conservation of species, ecosystems, and habitats.

These characteristics are presented in this document as a starting point for discussion at the Sub-Commission meeting, and no doubt there are additional considerations that can be added.

The decision whether to build a new hydropower facility must be evaluated against opportunities for the use of wind and solar (which seem to have fewer negative environmental impacts than hydropower), and the use of fossil fuels. Combinations of various modes of generating power should be compared. The tendency in the 20th century was to develop major electric power grids, with highly centralized production. Present technology allows for a more dispersed mode, with small, local generation of power by wind, solar, and hydropower. These have the advantage of increasing overall power stability, because down periods will be local rather than regional. If well co-ordinated, this dispersed mode could lead to small facilities for wind, solar and hydropower, involving small watersheds with more replications. One of the major environmental results of the 20th century hydropower development was the emphasis on the largest rivers, which are not replicated. For example, the Columbia-Snake River system in the Pacific Northwest of the United States has a very large water flow, and forms a system unique to that region. There is no system to serve as a comparison, or to provide direct redundancy. This has led to considerable confusion about the extent to which the hydropower facilities on this river system is the cause of the decline of salmon. Therefore, another guiding principle, at this time, would seem to be to move toward more dispersed, local, and independent power generation of several kinds, rather than the 20th century approach of the largest possible generating plants.

How to Make Renewable Energy Universally Available without Negative Consequences of the Use of Energy?

by Mr Michael EPSTEIN (Israel)
Solar Research Facilities Unit
Weizmann Institute of Science, Rehovot, Israel

Background

Each day hundreds of millions of people are making billions of energy choices in their daily lives, in producing goods, heating houses, driving to work, to name just a few. In some applications, energy generates output and income. In others, it provides convenience and comfort, or simply facilitates the business of life. Energy is one of the most important commodities for human beings. Its consumption has its roots in the ways economies and societies work.

It is widely recognized that energy demand rises with economic growth almost everywhere, but this coupling varies from sector to sector, from country to country and from period to period.

Fundamental social forces and policies, quite unconnected to energy use, affect housing, industrial structure, urban design and, vitally, transport infrastructure. These forces vary greatly among each one of the countries and societies, and they have profound impacts on energy consumption.

There is no general future solution for supplying energy and each country will have a different mix of solutions. In each country, analysts and legislators will have to frame policy strategies and programs to meet future demands and concerns.

One of the most acute of these concerns is the environmental problem associated with the production, transformation, distribution and consumption of energy, focusing on fossil fuels, whose combustion leads to CO_2 emissions.

Energy Efficiencies and Advanced Technologies

The increase of energy prices, especially after the first crisis of 1973, caused a significant shift in energy production and consumption, both technically and mentally.

The most important impact of this crisis is the increase of energy efficiencies. More efficient engines and designs lead to large reductions in fuel use per kilometer.

The energy intensity of home heating (ratio of heat used to home area) was reduced by 50% in some countries. The ratio of fuel use to output in manufacturing plunged by 20 to 50%, a remarkable drop, considering that the same ratio of electricity held constant or increased slightly.

Another significant impact is the shift to more efficient production of electricity.

During the last 25 years, there was enormous progress in gas turbines and combined cycles. Gas turbines (Brayton cycle) became very reliable, low-cost investment (about 60% less than in conventional power plants), more efficient (55% compared to 38–40% in conventional power plants − Rankine cycle), and their construction time is less than one year compared to 4−5 years for a conventional power plant. With gas turbines, the grid can be extended in a modular fashion. The developments in gas turbines changed also the share of liquid fuels in electricity production. More natural gas is used today for this purpose than ever. The use of natural gas reduced substantially the emission of CO_2 per Kw of electricity.

An additional impact is the transition to the use of coal for conventional power plants. The increase in the use of natural gas and coal in the last decade lowered electricity prices and made them less vulnerable to the changes in oil prices, certainly less than fuel for transportation.

Finally, the interconnection of national and regional grids with the improvements in electricity transmission makes the electricity commodity cheaper and available to remote areas. The 'globalization' of grids provides smoothing and storage of electricity, especially for renewable energy resources, which are intermittent and susceptible to climate variations.

RENEWABLE ENERGIES: SOLAR, WIND AND BIOMASS

The renewable energies, which are expected to share 30−50% of the primary energy in 2050, have undergone a significant progress since 1995.

The world PV market is experiencing a transition from those off-grid applications, which are considered by the purchaser to be 'economic' to a growing market for grid-connected applications. This market exceeded 200 MWe per year in 1999, and is expected to be 260 MWe per year in 2000 and 2,000 MWe per year in 2010 (it is expected that grid-connected PV will reach US$ 3/W in 2010).

Undoubtedly, wind power is undergoing a continued booming. Growth in wind turbines' sales has averaged 40% per year for the past five years. There are 14,000 MWe of wind capacity installed worldwide, 4,000 MWe of which were only installed in 1999. Expected installations in 2000 in Germany, Spain and Denmark are 5,600, 3,150 and 1,800 MWe, respectively, just to give some examples. Today's state-of-the-art turbines' cost is about US$ 1,000/kw of capacity.

Solar thermal power plants have not yet penetrated the market on a commercial scale. However, recent technological advancements demonstrated in the last five years, especially in connection with providing hot fluid into the topping of a combined cycle (solar Brayton cycle), have the potential of generating electricity at higher efficiencies and lower costs, compared to other renewables. Solar thermal power holds the largest potential among all the renewable energies. It will benefit from global grid, which can bridge the distance between the world largest potential solar site (the Sahara Desert) and the large market in Europe. In addition, solar thermal power can be used also to alleviate one of the highest challenges for technologists, as well as for policy makers: synthetic fuels for transportation.

The utilization of concentrated high-temperature solar energy to upgrade feedstock like low-grade coals, residual oil, wastes, etc., is one of the future major promises for this renewable resource.

Last but not least is the biomass. This resource offers tremendous opportunities for development, especially in developing countries, where 2 billions of people are currently without ready access to electricity, transportation, etc. In the 1990s, improved bioenergy technologies began to meet emerging market opportunities, such as cogeneration of heat and electricity in decentralized utilities, and the management of the urgent problem of municipal and industrial wastes.

The next decade will be dominated by the global policy driver of climate change mitigation.

A significant and sustainable contribution of biomass to energy and economy in the next few decades depends on the integration of bioenergy into the hydrocarbons market and, subsequently, into the hydrogen economy. Two vast challenges of integration are: biomass feedstock supply and compatibility of bioenergy products with the existing hydrocarbon markets.

POLICY ACTIONS

A number of policy steps are recommended in order to create the basis for achieving the global goals of energy accessibility, availability and acceptability.

- Recognizing that energy, as one of the most important commodities, requires clear and long-term planning. Allocating means associated with timeframe. Putting milestones to check progress.
- Keeping all energy options open, including traditional biomass, hydro, renewables, etc.
- Promoting higher energy efficiencies and energy conservation.
- Creating an adequate financing atmosphere for renewables linked to environmental aims.
- Investing in R&D.
- Advancing education and disseminating information.
- Making ethics a strong component of the energy system.

HOW TO HARNESS PROSPECTS FOR FUTURE ENERGY TECHNOLOGIES AND FOR EQUITABLE DISTRIBUTION OF THESE AROUND THE WORLD WITHOUT POSSIBLE NEGATIVE SIDE EFFECTS?

By Eng. (Dr) Ayodele A. ESAN (Nigeria)
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INTRODUCTION

Energy resources are now generally referred to under major groups - renewables and non-renewables.

The renewables include hydropower, solar radiation, wind energy, fuelwood and other biomass.

The non-renewables resources include crude oil, natural gas, coal and lignite, tar sands and nuclear fuels.

The very early concern in energy development and use was based on economics. Gradually with the developments in conversion technologies as well as end-use devices, education became the Rio Summit, environment was added as another element and recently sustainability.

The demographic trend globally gives a growth projection of 45% from 5.8 billion in 1996 to 8.4 billion in 2030 (UN, 1997). This growth of 45% is expected in developing countries and 4% in the rural population. Similarly, the percentage of rural populace is currently put at over 70% of the population in developing countries with inadequate energy.

The rural population in the developing countries over the years relied mostly on traditional energy such as cowdung, biomass, animals, human power and crop residues. It is only recently as a result in technology development trends that a gradual transition to modern (commercial) energy such as kerosene, diesel and electricity is manifesting.

BASIC HUMAN NEEDS

The basic needs of the poor and indeed beings are jobs, food, health services, education, housing, clean water, sanitation, mobility, etc. Energy plays an important role in ensuring these services such as cooking, lighting, heating, cooling, preservation, etc. The more accessible it is the higher the consumption by human beings, even the poor/rural population. The minimum energy required for cooking, lighting and heating is put as 1,040 MJ/capita/year for India.

Meeting human needs

A recent study has shown that only 7% of the world's electricity production are required to cover basic human needs. This is because electricity is ever more the key to modern world. In other words, it is imperative and necessary to harness energy for human productive uses. This actually is what WEC stands for "to promote the sustainable supply and use of energy for the greatest benefit of all". The resultant effect is the escape from cycle of poverty, especially for the rural populace. Since broad access to rural energy will bring about increased economic activities and productivity in areas such as agriculture, industry, transportation, services, domestic (urban/rural), etc.

PROMISING TECHNOLOGY DEVELOPMENT

Technology generally transforms life, both in the urban and rural areas. Greater focus and investments/interventions in the past have been on urban products, while products for rural areas have been technically inferior and offer poor value for money. Also traditional energy technologies are inefficient with drawbacks in natural resources, health issues and social implications.

Technologies that offer the potential for progress in rural areas span generation, transmission, storage, metering and billing, hybrid systems, micro-hydro turbines, fuel cells, solar and wind power, etc.

Proven technologies challenges

1. Metering and billing

   Tariffs/revenue collection primer challenges are institutional, administrative and political. This is followed by maxi. demand – limited by current limiting devices such as mob, thermistors, and electronic cut-outs.

2. Electrical energy services technologies

   End-use technologies such as incandescent bulbs, kettles, two-plate stoves, irons and resistance heaters.

3. Electricity generation technologies

   These are solar p.v. wind power, micro-hydro plants, large scale biomass based generation, (sugar mills), gasification technology systems, diesel/petrol gensets, fuel cells, smaller biomass based technologies, small gas turbines.

4. House thermal energy needs

   These are cooking, primary, space and water heating as secondary. There are clear trends to the use of modern fuels such as kerosene, gas and electricity.

Range of technologies are woodfuel, solid biomass, combustion, kerosene, LPG, natural gas, biogas and solar.

5. Agriculture

   Areas of need are in irrigation, livestock-water pumping tillage, harvesting, wind pumps, p.v. powered pumps.

6. Transport

   Biofuels technologies to be considered are biogas, wood gasification, and ethanol production. Meeting energy needs in this area tend to change rural livelihoods.

EQUITABLE DISTRIBUTION

This is more likely to be influenced by the demand/supply scenario. It is important to state that income-level is an influencing factor on energy consumption. Low income level consumes, energy primarily in cooking, while medium income will add lighting to its energy consumption and the high income will add water heating, refrigeration and cooling to those of medium income level.

Other influencing factors will be adequacy, convenience, social economic, cultural growth trends, development trends, and financing and technological capacity.

CURTAILING NEGATIVE SIDE EFFECTS

A gradual transition to modern energy systems is preferred with greater efficiency in end-use devices. Switching to more efficient modern energy systems involves initial support capital cost. Hence the need for a rural micro-credit scheme as fiscal measures to facilitate adoption of these systems.

Activities and measures to curtail negative side effects include capacity building, training, human behaviour/reorientation, monitoring and regulation, maintenance culture and research and development.

WAY FORWARD/HOW?

State of technology

Many are in a state of rapid development, or have already being commercialised and can be regarded as mature. In some cases, real costs are decreasing significantly. Increased research and development investments are necessary.

Adoption/Acceptance of technology

Generally, adopting any technology is dependent upon the availability of technical resources, access to necessary finance, accessibility of information for decision-making by planners/local community, local people participation, etc.

Barriers removal

In adopting any of these technologies, generally there are barriers to be removed such as awareness creation, statistical data acquisition on energy use patterns, improving earning power, rural development, etc.

Measures/Strategies

i. Bottom-up, people-led development shows the best promise of achieving sustainable development.

ii. The focus should be on the effective use of scarce development resources.

iii. Integrated rural development with other measures dealing with agricultural, educational, infrastructure, social and political factors.

iv. It will/might be necessary to put in place measures for successful implementation such as policy, framework, fiscal-subsidies/substitution, institutional, infrastructure.

v. Building up regional centres of expertise to facilitate inter-regional support and information sharing.

vi. International organisations involvement for capacity-building and applicable projects, e.g. NGOs, articulating programmes/needs to governments and putting projects/programmes in place.

- FAO: experience in agriculture and rural sector.
- WEC: global network, regional programme resources, GEIS, raising issues with policy makers.

Challenges

Some of the important and difficult challenges are financing, training/human resources development, information dissemination, local participation, and cultural considerations.

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3. Indian Advisory Board on Energy – Minimum Energy Indicators.

HOW TO PROVIDE BIOMASS ENERGY IN A SUSTAINABLE WAY THAT MINIMIZES NEGATIVE ENVIRONMENTAL AND SOCIAL (INCLUDING ETHICAL) CONSEQUENCES?

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WHAT IS BIOMASS ENERGY?

Biomass energy is derived from the byproducts of living plant cells, which are produced and propagated by the carbon cycle. This cycle, using photosynthesis, converts (fixes) atmospheric carbon, water and nutrients into organic matter using the energy from sunlight. Although biomass energy is primarily derived from plants, it can also include the waste products of animal or human origin mainly originating from the ingestion of plants. Under this definition, biomass energy refers to organic compounds comprising essentially carbohydrates, lignin, lipids and plant protein. Carbohydrates in the form of cellulose, starch and sugars are the main group with cellulose being the most abundant form of carbohydrates. Nicolas Théodore de Saussure first proposed the photosynthesis reaction in 1804[1]:

$$6CO_2 + 6H_2O \xrightarrow{Sunlight} (CH_2O)_6 + 6O_2$$

$$\downarrow$$

Hexose $\longrightarrow$ Carbohydrates

Wood is the oldest fuel known to humans. Since the discovery of fire, it has been harnessed for energy. The end product in the combustion of biomass is carbon dioxide and water, completing the carbon cycle:

$$(CH_2O)_n + nO_2 \xrightarrow{combustion} nCO_2 + nH_2O + heat$$

1. Saussure, N. T. de (1804). *Recherches chimiques sur la végétation.* Nyon.

Current examples of the use of biomass energy are the burning of fuelwood, agricultural residues and urban wastes. Where fuelwood is scarce, alternative biomass fuels are used such as agricultural straw, husks and animal dung. The heat produced from burning these fuels is used for cooking, home heating and power generation. Biogas is also produced for fuel from the anaerobic digestion of sewage, animal waste, and garbage.

In addition to stationary applications for biomass energy, ethanol is produced by the fermentation of carbohydrates such as sugar cane and starchy crops for transport fuels. Alcohol, consisting of 95% ethanol (and 5% water) from sugar cane is sold in Brazil for specially tuned automobile engines. A blend with gasoline of up to 10% ethanol is used interchangeably in normal engines in a number of countries with ethanol derived from a range of starchy crops. These carbohydrates are also basic food sources and are much less abundant than lignocellulose, the major constituent of the plant kingdom. Wood cellulose was converted to sugars by acid hydrolysis and fermented to fuel ethanol in a process developed in Germany in the 1930's. Commercial production has not been favourable with availability of oil at competitive prices resulting in the closure of the remaining plants in Russia in the early 1990's. Other liquid fuels such as methanol from lignocellulosic biomass proposals have been considered, but not implemented. Methanol can be further converted into diesel and gasoline. Interest in lignocellulosic conversion has increased with shortfalls in world oil supplies and price increases. Similarly, vegetable oils, particularly in the esterified form, have been shown to be effective in operating diesel engines.

The importance of biomass energy is shown in the world's production of fuelwood and charcoal. According to the Food and Agriculture Organization (FAO), production was 1.87 billion cubic metres in 1996. It is the largest single use of wood representing 56% of the total roundwood produced worldwide. However, the actual usage could be even higher as the official production and consumption statistics vary widely depending on their bases. Unlike commodity energy sources that have well documented production, sales and consumption figures, biomass energy data does not always account for the significant resource that is gathered and used by individual households particularly in developing countries.

BIOMASS ENERGY AND THE TYRANNY OF DISTANCE

Unlike coal mines, oil and gas fields, which are highly concentrated sources of energy, biomass is very dispersed over the surface of the earth. This means that it is well suited to *in-situ* applications or regional use but costly to collect, centralize, process and distribute. Generally, the resource has less energy in terms of both weight and volume than most fossil fuels. Thus fuelwood and agricultural residues are often used by the poor as a free, or low cost fuel. The effective distance for application is within a carrying distance of several kilometres. Commercial fuelwood may have an economic transport distance of around 100 km.

Biomass has a low energy value per unit weight, typically 25% of that of oil. The bulkiness further lowers the energy density for transport and storage considerations. It can however be upgraded into higher value fuels with improved burning characteristics such as briquettes and pellets (with an oil equivalence of 40%) and charcoal (74% of oil), for transport to more distant markets. Transport distances could be effectively doubled for the densified fuels and increased fourfold for charcoal.

Where concentrations of biomass exist as a result of other production activities, such as residues from timber, paper, and sugar mills, these are economically attractive energy sources. Biomass fired power stations with generation capacities of up to 55MW are in operation based on residues. Wood tars from centralized charcoal production sites in Brazil have been used as a liquid fuel in steel making.

SUSTAINABLE PRODUCTION OF BIOMASS

The carbon cycle shows that when biomass is burnt for energy, it produces carbon dioxide but if the plant source is regrown, then the carbon dioxide is reabsorbed by the plants and fixed in the new plant matter. This process is sustainable as long as the production rate is greater than, or equal to, the consumption rate. Under these conditions, biomass energy is available in perpetuity. This conforms to the conditions for sustainability implied in the Brundtland Report (1987) that we satisfy the requirements of the present without compromising the possibility for future generations to satisfy their own needs. However, if consumption exceeds the regrowth rate, the situation can lead to environmental degradation. Sustainability therefore depends, in part, on balancing biomass energy demand and supply. Sustainable demand may require efficient use or reduced consumption. If voluntary, or pricing measures are unsuccessful, then the energy resource would need to be rationed. In addition to economic considerations, other sustainability factors need to be considered. The following looks at ways of increasing supply.

1. Land-use considerations

The collective desire to produce food crops and raise cattle and other domesticated livestock created demands for arable land resulting in the clearing of forests and woodlands. In 1988 and 1997, the uncontrolled land-clearing operations by slash and burn in South America and South East Asia, respectively, contributed to the highest measured rates of increase in atmospheric carbon dioxide from human activity. Advances in productivity of food crops and farming practices are expected to more than meet the current and projected future demand for food and the need for large tracts of new arable land must be seriously questioned. Consideration can therefore be given to the establishment of energy crops or energy plantations on land surplus to agriculture. Land that has been degraded by nutrient depletion, loss of soil structure, soil erosion and salinity is also a likely candidate for use. Other suitable areas are mining sites requiring rehabilitation and land contaminated by toxic waste. Biomass supply can also be increased by planting multiple-use trees such as for both energy and shelter windbreaks.

2. Increasing biomass yields

Species selection and genotype development can increase growth rates by as much as tenfold. Mean annual increments of eucalypt trees in Brazil have been reported as high as 60 cubic metres per hectare per year[2]. Brazil has over six million hectares of eucalypt plantation forests, most of which was initially planted for charcoal making. Sweden has led the development of fast growing, intensively cultured hybrid willows for energy production.

Growth rates also depend on availability of nutrients and water. The essential nutrients are nitrogen, phosphorus and potassium while calcium levels and trace elements are also important. The following opportunities exist to enhance biomass energy production through recycling:

- ash produced by burning biomass fuels contain potassium, calcium and phosphorus;
- sewage is a source of nitrogen and phosphorus provided the levels of pathogens, heavy metals and toxic compounds can be controlled;
- water runoffs from farms into waterways can contain excess fertilisers which pollute streams and rivers. The establishment of a buffer strip between agricultural land and streams with willows has been effective at reducing nutrient pollution and provides a source of biomass energy;
- nutrient contaminated groundwater near landfill dumps has been used to irrigate energy plantations in Sweden.

The symbiotic planting of multiple species can increase biomass yields. In South Africa, the clearing of acacia trees and scrub often result in profuse regeneration. One practice is to plant eucalypt seedlings immediately after clearing. Because the acacias are leguminous, they fix atmospheric nitrogen in the soil. This benefits the eucalypts, which grow faster than the acacias and eventually dominating and suppressing the acacias into understorey trees.

2. Nambiar, E.K.S. (1999) *Pursuit of Sustainable Plantation Fforestry.* Southern African Forestry Journal, No. 184, March 1999, pp. 45-62.

The inoculation of mycorrhizal fungi in the soil can assist plants to better access phosphorus locked up in soils. These measures will help increase the biodiversity of plantation forests .

3. Increasing energy conversion efficiency

Increasing the efficiency of conversion to useful forms of energy helps sustainable production. This means that less resource is used for a unit of energy produced. The following lists opportunities and examples of improving conversion technologies across the range of applications of biomass energy.

- Domestic cooking stoves are often very inefficient. The "three stone stove" is used in developing countries because of its simplicity. Little of the heat is utilized in the cooking process, as most of the energy is lost to the surroundings. Efficiency improvements have been achieved through fundamental and applied research such as the "bucket" stove in Thailand, which identified and quantified the sources of energy loss. This led to design improvements namely limiting excess combustion air, insulation and reducing the thermal capacity of the appliance. Good design for manufacture by cottage industries using locally available low cost materials and production methods ensures affordability.
- Industrial stoves have also been studied such as those used in the evaporation of palm sugar syrup by cottage industries. The "two-pan stove" developed in Thailand utilized the waste heat passing the evaporation pan to heat a second pan to boost efficiency. This was designed to cut the fuelwood usage.
- Home heating with traditional fireplaces and stoves is often inefficient and produces smoke. Better technology can be developed and standards set for rating the performance of these appliances to help consumers choose.
- Likewise, industrial heaters and boilers should be rated for efficiency, which will enable the establishment of benchmarks as a basis for technology improvements.
- Power generation from biomass using the conventional steam cycle has maximum efficiencies of around 20-25%. Cogeneration efficiently produces both electricity and useful heat increasing the overall efficiencies to 60%. However, the trade-off is a marked reduction in electricity output. Development of gasification combined cycle generation systems in USA and the UK using a combination of gas and steam turbines with an output of about 10 MW is expected to increase the generation efficiency to above 30%. On a smaller scale, interest in developing biomass systems to operate microturbines and fuel cells could provide efficient distributed generation.

- In ethanol production, improved utilization of the lignocellulosic feedstock could make this more economically attractive. Lignocellulose consists of the components: cellulose, hemicellulose and lignin. Ethanol is derived from the cellulose fraction, which constitutes a third of the biomass. Research and development over the last two decades has been the improved systems for pretreatment, which mechanically releases the cellulosic components for conversion, and combined hydrolysis and fermentation of cellulose using genetically modified micro-organisms. Utilization of the hemicellulose component has shown promise but better uses for the lignin by-product are needed.

4. Recycling waste for energy

Use of biomass waste for energy is sustainable and desirable. These wastes are usually already centralised and can be converted by combustion for heat and power[3] and upgrading to solid and liquid fuels. In addition, landfill dumps produce biogas containing a high methane content which can be used to generate electricity. Animal waste can be used to produce biogas in anaerobic digesters.

THE ROLE OF BIOMASS ENERGY IN MINIMIZING ENVIRONMENTAL IMPACT

When renewable biomass energy is used to substitute fossil fuels, it helps to reduce greenhouse gas (GHG) emissions, therefore decreasing the risk of climate change. For every unit of useful energy produced by a renewable resource means that the equivalent fossil carbon source could be left in the ground and saved for future generations. The renewable status of biomass energy is applicable only if it is used sustainably. Overexploitation and unbridled use of the resource for energy must be avoided as it is ecologically damaging leading to deforestation and loss of vegetation on a large scale. This not only adds directly to GHG emissions through combustion processes but also further increases GHG levels by reducing the sequestration potential of trees from the loss of forested areas. Loss of forest habitats would be detrimental to biodiversity and the landscape could become badly scarred by soil erosion and land degradation.

The use of forest industry and agricultural residues, building and demolition wastes and urban garbage for energy production helps to reduce the need for incineration and landfill sites which are poor environmental practices. Utilizing forest harvesting residues and forest debris for energy could help reducing the risk of destructive forest fires

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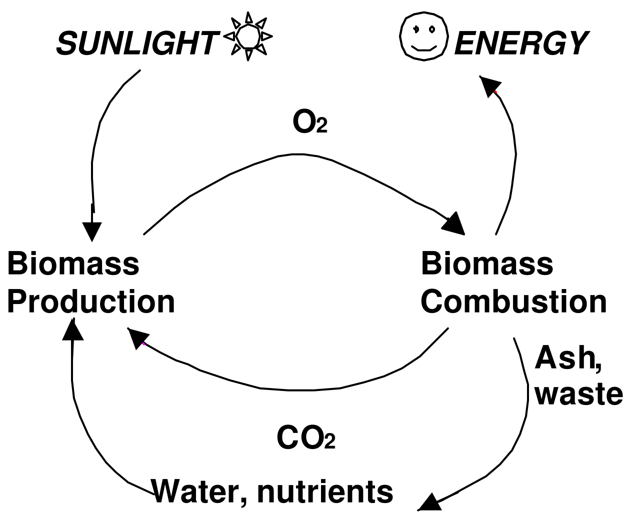
3. Raison, J. (1999) *Environmental Requirements for the Generation of "Green" Electricity from Wood.* Report on the "Investigation of Potential for Electricity Generation from Forestry By-Products in New South Wales", June 1999 for the Sustainable Energy Development Authority NSW, Australia, pp. 174-178.

where there is accumulation of fuel on the forest floor. The excessive forest woody matter could form an impenetrable mat impeding the growth of seedlings and the regeneration of the forest.

However, fuelwood harvesting can have impact by reducing habitats for hollow dwelling animals. Where soil compaction from harvesting machinery can occur, some harvesting residues should be left on site. In addition, the leaves, bark and small woody twigs should be left to maintain organic matter in the soil and nutrient recycling.

Biomass can be a clean burning energy source. It is low in sulphur content and burns with negligible production of sulphur dioxide pollutant. Generally, the lower combustion temperature of biomass fuels helps to reduce emissions of oxides of nitrogen.



SOCIAL BENEFITS OF BIOMASS ENERGY

Biomass is a simple fuel with a strong rural base found in most rich and poor countries alike. As an energy source, biomass is attractive because it is renewable, abundant, readily available and accessible. It is a familiar resource as most people know how to grow plants. It beautifies our landscapes and provides habitats for other creatures. Plants are an integral and essential part of our environment as it also provides the oxygen we breathe, the food we eat and the materials to build our shelters and household goods.

Advances in biomass energy such as distributed conversion processes could bring higher forms of energy to rural areas. An example is rural electrification. In developing countries this would improve the standard of living, increase employment opportunities and provide better education for the younger generation. Distributed conversion would spread the ownership to a greater number of individuals, families and communities. In urban areas, opportunities also exist in converting garbage to energy, reducing the environmental impact of disposal.

For developing countries with the potential to produce a significant, sustainable biomass energy resource, there are good opportunities to build an economy based on renewable energy, which would minimize fossil fuels imports and improve the balance of payments. The effect could increase the nation's standard of living without adding to GHG emissions.

ETHICAL ISSUES

The tyranny of distance helps protecting the common ownership status of this fuel to essentially the occupants of the land on which it is grown. Fossil fuels, such as oil, are normally owned by entities with no direct connection with the land. Here, remote governments and resource companies capture all the value. In developing countries, citizens can receive little or no benefits and, at worst, they loose their livelihoods by inheriting the resultant degradation and pollution of the environment. If wider use of biomass energy is developed, property rights of the occupants should be protected to foster sustainable production. If the resource is farmed or grown in plantations, the ownership issue is clear but is less so for native or indigenous biomass.

The multiple demands on biomass for fuel and food raises the issue of priorities in feeding a nation's population and the need for foreign exchange. If a nation cannot feed itself and cannot produce enough external income to import its food requirements, it will need to carefully balance food production and energy. This will impact on collective decisions such as crop selection and land-use. Assistance from other nations must also be available to help underprivileged peoples in times of need. If other nations were not moved by a duty of care, the longer-term changes would impact on the global community.

The fact that the extent of accumulation of GHG and its effect on global warming and climate change is predominantly caused by the wealthy nations raises an important issue. These economies are currently founded on energy intensive industrialisation and lifestyles based on non-renewable sources. The targets for GHG reduction through the Kyoto Protocol would be jeopardized if developing nations significantly increase their GHG emissions. Should the developing nations therefore be burdened by restrictions as well? This would severely limit their drive to develop their economies and improve living standards. If the wealthy nations are prime producers of present and past GHG, they must take some responsibility for the sustainable development of the poorer nations. If there were no support, developing nations would be forced to resort to cheap, polluting technologies, following the same course as the Industrial Revolution in Europe, which relied heavily on fossil fuels. This course would compound the pressures on GHG emissions with even greater risk of global climate change. Industrialized nations should therefore take greater responsibility in developing renewable energy and help advance the rural sectors of the poorer nations that is within the capacity of their ecosystems for sustainable development. Achievement of this goal would be equivalent to a new, green industrial revolution.

THE ETHICS OF ENERGY - INTRODUCTORY REMARKS

by Mr James Peter KIMMINS (Canada)
Chairperson of the Sub-Commission

INTRODUCTION

Energy is what biological life is all about. Outside of a religious interpretation, living organisms and dead organic matter are merely solar energy harnessed as the energy linking the elements of complex molecules.

Because life is a manifestation of energy, life obeys the laws of thermodynamics. The second law says that while energy cannot be created or destroyed, only transferred from one form to another (the 1^{st} law), no transformation can be 100% efficient. A portion of the energy being transformed is always degraded to a lower state of organization as heat. A consequence of this transfer inefficiency is that the energy state of all systems has the tendency to continually decline; its entropy or level of disorder tends to continually increase. Only if there is a continual input of higher level energy can a system remain organized and function normally.

As a consequence of the second law of thermodynamics, life on earth would cease to exist without energy inputs. Terrestrial and most aquatic ecosystems would collapse if light from the sun were blocked. Similarly, human societies as we know them today would collapse if sources of external energy were cut off.

Until humans harnessed external energy sources, we were essentially no different from any other animal member of the food chain. Social organization and the use of tools to greatly increase our effective speed, strength and ferocity certainly improved the competitive status and survival of early humans. However, the major divergence in the evolutionary "strategy" of Homo Sapiens compared with other animals awaited the harnessing of external energy sources.

The earliest extra-human energy source used by humans was fire, which enabled them to modify or remove forests and alter vegetation in a way that human strength on its own could not. Fire was also used to promote food species and facilitate their collection or capture. Later, the power and speed of animals such as oxen and horses greatly extended the ability to do work and the speed of movement, while the speed of birds was used to hasten communication. Fire and water were used to promote early agriculture, and were harnessed as a source of power. Harnessing the energy of wind speeded travel across water and provided a power source on land.

The sophistication of human energy sources has increased steadily over the past century, but the fundamentals have changed little. Organic food (solar energy in biomass) is still the source of metabolic energy for humans, as it always has been. The strength of animals is still widely used in agriculture in developing countries. Most of our extra-human energy sources remain based on fire, water and wind; only the fuel for the fire and the means of using the power of fire, water and wind have changed. Wood has largely been replaced by the fossil fuels of coal, oil and gas. Storage of wind and water energy as electrical energy has replaced its conversion to and use as mechanical energy. The conversion of solar energy to electricity constitutes a variation on photosynthesis in which plants store solar energy as biomass, which has been a traditional energy source, and is sometimes used today to generate heat and electricity. The development of nuclear energy represents a uniquely new departure from traditional energy sources, and the use of geothermal and tidal energy also represents relatively new energy sources.

THE INFLUENCE OF ENERGY ON THE DEVELOPMENT OF HUMAN SOCIETY

The harnessing of extra-human energy has given to humans physical abilities of strength, speed and power that far exceed the biological capabilities provided to us by evolution. This has greatly increased the competitive abilities of humans and has permitted us to expropriate the ecological niches of many other species. It has given us the ability to alter ecosystem conditions at will, and often in ways that are detrimental to both us and other species.

Within the human species, societies that have successfully harnessed extra-human and extra-animal energy sources have been militarily dominant, economically powerful, have controlled access to resources, and have enjoyed standards of living far in excess of societies that have failed to secure such an expanded energy base. Access to cheap energy has promoted improved education, health, food and water, communication, pollution control, and transportation. Energy is thus interwoven in all human endeavors and has been a major determinant of their success, and for people who lack cheap, portable extra-human energy sources, much of their time and energy is invested in finding food, fuel and water, leaving few human resources for education, culture and improvement in the human condition. Use of biomass as fuel has been a major source of deforestation around the world.

Recent increases in the price of fossil fuels and interruptions in supply have provided a dramatic example of the degree to which Western societies is addicted to cheap, portable and abundant energy sources. From health to food and water supply, from transportation and travel to the maintenance of desired temperatures in our living and working environments, and from communication to entertainment, virtually everything in Western industrialized societies is energy-dependent. Dispersed rural populations with much lower standards of living are less dependent on technology-related energy sources, but much of the world's population is now located in cities. The loss of the energy needed to sustain these urban systems has the potential to result in consequences that in aggregate would differ little from the effects of war. As a consequence, energy-addicted Western societies jealously guard the energy supplies needed to maintain peace, harmony, health, and social organization in their countries.

As access to energy declines, either because of absolute availability or because of cost, it is the poor of the world that suffer most. Economic disparities between countries are closely related to energy availability, and to how energy and energy revenues have been allocated by the governments of those countries. Economic disparities within countries are similarly related to unequal access to energy and energy-related wealth and resources. As fossil fuel supplies decline, the most negative consequences will occur in societies that have just entered the low-technology fossil-fuel-dependent stage. Technologically-advanced countries will be in a better position to develop alternative high technology energy sources, and to improve energy use efficiency. Poor countries that have not yet fully entered the fossil fuel-driven technology stage will have their social and technical evolution retarded, increasing the disparity of wealth, health, education and overall standard of living between the poorest and wealthiest countries.

Within developed countries, the poorest sector of the population will be the least able to deal with the consequences of increased cost of energy. Shelter, warmth, food and everything else in society will become more expensive and thus less accessible to the poor. On the other hand, in many countries, increasing fuel costs may increase government revenues, presenting the opportunity to address poverty and the consequences of any energy crisis for the poor.

THE ETHICAL CHALLENGE OF ENERGY

While it could be argued that access to food and water are the most fundamental necessities for life, access to these resources is closely related to the price and availability of energy. In fact, almost any aspect of human endeavor is related to a greater or lesser extent to energy cost and supply. A consideration of the ethical aspects of these endeavors will, therefore, involve an analysis of energy.

In a similar way, consideration of energy issues has implications for many other aspects of human society. Use of fossil fuels has been identified as a major contributor to global climate change, with serious ethical implications. Replacement of fossil fuel by hydro electricity involves dam construction and flooding, displaces rural populations, destroys forest and wildlife habitat, interferes with fish populations, and changes sediment transport and deposition patterns. The construction of concrete dams releases large amounts of greenhouse gases to the atmosphere, and in many areas dams have a limited life span. Decommissioning dams raises significant environmental questions, is very costly, and will require further substantial releases of greenhouse gases.

Development of nuclear power, once seen as the answer to the energy dilemma, has proven to be difficult, a potential health risk, and less reliable and more expensive than initially predicted. Solar energy, geothermal energy and wind have significant potential for generation of electricity in some areas, but may involve aesthetic alterations to human environments that are deemed unacceptable. Tidal and wave action as a source of energy have been little developed, and while they could have local significance, energy storage and distribution issues remain to be solved, and there may be environmental and aesthetic constraints .

CONSIDERING THE FUTURE

There is little reason to believe that humans will be unable to overcome the present limitations to energy supply. Hydrogen-based fuels produced by non-polluting renewable energy should be able to replace fossil fuels, and the energy efficiency of engines will continue to increase. Super conductors will facilitate the distribution of energy, and much more efficient means of storing electricity will be developed. The energy efficiency of transportation and travel systems will increase greatly, and the development of virtual reality communication systems will greatly reduce the need to travel. More energy efficient housing and working environments will reduce the need for air conditioning and heating.

This is an optimistic outlook. The speed at which such energy developments will occur will be determined more by the cost and availability of traditional energy as by human ingenuity. If existing energy sources remain cheap, the transition to a more sustainable society will be slow. This would be better for the poor and disadvantaged of the world but much worse for the environment and other species. The transition would be greatly accelerated by increases in cost and reductions in supply of energy; necessity has always been the “mother of invention”. This would be good for the environment, much better for humans in the long run, but would have dramatic and often socially undesirable consequences in the short-run. Ethical considerations alone may act to slow the transition because of effects on food, heating, health, transport and other necessities for the lower income segment of society.

We thus face an enormous ethical dilemma. How do we balance short-term social costs borne largely by the poor, the disadvantaged and the undeveloped nations (costs that may in the short-term increase the disparities between rich and poor nations, developed and developing nations) against the longer-term benefits of moving to a more sustainable society and protecting the global environment?

In examining this dilemma we must be continually aware of the complexity of energy issues and their "interconnectedness" to every other issue that COMEST is now, and will become, concerned with. For every potential solution to individual energy issues there will be a social cost, an ethical dilemma, and an impact on the solution of issues in other human endeavors. This Sub-Commission must be constantly mindful of this complexity, and must seek to embed our consideration of individual and overall energy issues within a broader consideration of the functioning of the world system of which energy is only one, but an intimately interwoven, sub-system.

THE DILEMMA OF ENERGY DEMANDS FOR DEVELOPMENT AND AN ECOLOGICAL CONSCIENCE IN DEVELOPING NATIONS : A CHANCE FOR AN ETHICAL APPROACH?

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Member of COMEST

ENERGY: THE BACKBONE OF LIFE

Life on Earth is completely dependent on the extraction and transformation of energy. Energy capture and transformation has been at the very core of the evolutionary process ever since life has existed in this planet. From its origins, humankind has been drawing energy from the natural systems which surround it, first as a source of food, whether hunting or gathering, or later through the Agricultural Revolution, from the modification of the landscape and the species which were manipulated to be converted into crops or domestic animals. Until the late 17th century, the energy tapped was mostly the solar energy and the energy invested was the human and animal caloric cost of the agricultural labour. A negative balance between energy invested and harvested simply meant famine and death. Later on, fossilized solar energy-captured and stored in geological strata through aeons - entered in the play and generated a completely new scenario. Hydropower and a relatively smaller but environmentally significant use of nuclear energy have complemented the satisfaction of such energy needs.

Energy demands through agricultural activities and industrial development constitute the most phenomenal sources of environmental impact that a species has imposed on the planet's natural systems. Based on mathematical relationships relating body size with habitat area, human populations are estimated to have reached over 30 times the extension expected, had agriculture not been invented. Humans have expanded the carrying capacity of Earth by "importing" energy stored in the past, but also by concentrating the wastes resulting from its massive and concentrated use in time. This growth, obviously, has had an environmental cost [1]. Agriculture has been described [2], very rightly,"as the most environmentally devastating human activity on Earth".

Fossil fuels account for over 80% of the energy consumed in the world, with nuclear energy accounting for less than 10% and now in a process of reducing its role in energy consumption. Alternative and renewable sources of energy are still, to all practical purposes, in their infancy and account for a very small fraction of the total energy consumption.

Never before the Industrial Revolution, has human activity been capable of modifying so profoundly and extensively the natural ecosystems, the landscape and the atmosphere of the Earth. Changes on those systems have been part of the history of this planet. What is profoundly different is the *rate* at which those changes have taken place in the last 250 years or so. Recent research suggests that rates of species extinctions in this century have occurred up to 1,000 times faster than in pre-human eras. Based on rates of habitat extinction and field observations, it is estimated that close to 13% of the world's species may go extinct before 2015. Much of this loss will occur in species-rich developing nations.

Notable results of such profound modifications are the unprecedented and sustained loss of natural ecosystems which contain Earth's biological diversity and provide essential ecological services, the depletion of the ozone layer, the unnatural concentration of certain gases in the atmosphere causing a greenhouse effect and the consequent climatic changes. Besides the permanent flow of scientific information directly coming from observation directed into the phenomenon of global warming, a number of everyday events punctuate what by now is a fairly well-established picture of what the effects of energy consumption around the planet are. The observation by French researchers that the concentrations of greenhouse gases were at their highest recorded concentration in history in 1999, the atypical heat waves outside of their normal summer seasons in the Northern hemisphere, the observed disruption of migratory patterns of butterflies, among other organisms, the extreme climatological events such as severe droughts or rainstorms, extreme low or high temperatures, are all increasingly frequent symptoms reminding us of the process of heat entrapment in the atmosphere occurring by the constant increase of greenhouse gases.

PRESENT AND FUTURE DEMANDS OF ENERGY IN DEVELOPING COUNTRIES

Although until recently developing nations which constitute about 75% of the world population represent a smaller proportion of global energy demands (about 40% of total) and consequently of carbon emissions (about 30% of total), their population growth and the demands *per capita* will grow considerably during the following few decades, so they will represent close to half of total energy demands and more than 50% of carbon emissions (Table 1). The 2 billion poorest people (less than 1,000 $US annual income *per* capita) living in developing nations, use only 0.2 toe (tons of oil equivalent) of energy *per capita* annually, while the one billion richest people (annual *per capita* income of >22,000 $US) consumes almost 25 times more energy per person than their poorest fellow human beings.

When the Industrial Revolution started, the CO^2 concentration was estimated at 280 ppm; by the end of the 50's the levels had risen to 316 ppm and by the end of the century it had risen to 367 ppm. Average global temperatures climbed from 13.99°C to 14.43°C, a gain of almost half-a-degree centigrade. Projection of temperature increase for the next century may involve sea-level rises of between 17 cm and one meter. Already important ecosystems like coral reefs the world around is showing the disastrous effects of these changes. There are suggestions that more than half of the extension coral reefs in the Indian Ocean may have been destroyed as a result of climate change.

Table 1. Present-day demands and projections of energy and carbon emissions for developing nations

	ENERGY CONSUMPTION *(10^{15} btu)*			CARBON EMISSIONS *(million metric tons)*		
REGION	**1996**	**2010**	**2020**	**1996**	**2010**	**2020**
Industrialized Nations	202.5	240.4	262.8	2.98	3.535	3.907
E. Europe/FSU	52.4	61	69.8	842	935	1.024
Developing Countries						
Asia	74.5	127.6	177.9	1.474	2.426	3.377
Middle East	17.3	27	34.7	283	434	555
Africa	11.1	15.5	18.9	198	270	325
Central/ S.America	17.7	32.6	47.7	206	418	629
TOTAL DEVELOPING	120.6	202.8	279.2	2.161	3.547	4.886
TOTAL WORLD	***375.5***	***504.2***	***611.8***	***5.983***	***8.018***	***9.817***

Stabilizing Earth's climate will require necessarily a serious reduction of carbon emissions by shifting from fossil fuels to renewable sources of energy. However, these so far have been developed at a very slow pace. Globally these sources represent less than 10% of total energy consumption. Five countries account for slightly over 85% of renewable energy generation (geothermal, solar and wind, excluding bio-fuels) in the world: the US, Brazil, Philippines, Mexico and Italy. (Table 2). Biomass remains as the major source of energy for rural populations, and will continue to be so, provided it remains as an affordable and reliable source.

Table 2. Leaders in use of renewable energy
(1997, 10^{12} Kwh).

United States of America	86.8
Brazil	9.4
Philippines	5.9
Mexico	5.2
Italy	4.5

this represents 85.2% *of World total*

Source: US E.I.A.

The main drivers of energy requirements are: a) population size and b) the demand *per capita* which is normally related to the economic affluence of people. Both factors will increase considerably in most developing countries, forecasting higher levels of demand for energy. Table 3 shows projections to 2020 for population increases and changes in economic affluence estimated as GDP *percapita*, with the resulting *per capita* and total energetic demands. Latin American levels of affluence will be close to those which are current today in Europe.

Table 3. Drivers of energy use in developing countries in 2020

	Population *(10^6)*	**Energy/Capita** *(toe)*	**Total Energy** *(Mtoe)*	**Affluence** *(GDP/Capita US Dollars*
Latin America	840	1.1-1.6	924-1,344	16,000
Sub-Saharan Africa	1,800	0.5-0.7	900-1,260	1,500
Middle-East & N. Africa	850	1.2-1.6	1,020-1,360	4,800

Combined estimates from WB, UN, OLADE, IIASA, WEC

Evidently, these drivers will mean important increases of energy and an elevation of carbon emissions in the next two decades. This is something unavoidable, but apparently the effects may be somewhat less severe, judging by the form in which energy use *per capita* and energy use *per dollar* is predicted to perform in the year 2020 at the global level (Fig. 1). The UN 1990 medium term population projection for 2020 had been reduced by 700 millions at the end of the 90's. Economic growth has been *ca.* 1% slower than predicted for the 90's. Whether this pattern of energy demand will be also representative, at least in part, for developing countries is still to be seen.

CHOOSING ECOLOGICALLY SUSTAINABLE ENERGY USE SCENARIOS IN THE DEVELOPING WORLD

It is not possible to plan for any scenarios of sustainable development and the adequate satisfaction of societal needs, if the environmental impacts of the levels and types of energy demands are not properly assessed. To do so, nations must have available not only adequate methodologies, but also relevant information which includes sources and processes of energy transformation, end-user characteristics and, specially, the environmental impacts of the energy technologies utilized. Several developing countries have proposed and utilized methodologies to carry out such assessments. As an example, I will refer to a recent study carried out for Mexico [3] in which quantitative data about quality, quantity and renewability of available energy, as well as characteristics of the end-use technologies were used, analyzing different scenarios for the next 25 years. Data is presented in Table 4. The results underline both the fact that much information is needed to make a better assessment of the environmental impacts of the different energy use scenarios, but also that levels of *per capita* consumption around two or three times as large as that presently occurring in Mexico could provide both adequate satisfaction to the energy needs of the population which will be present in 2025 (some 130 million people) and will represent a sustainable or conservationist scenario. One of the keys to achieve these scenarios is the increase of the relative importance of renewable energy to up to one-third of the total demands. Conversely, a "business as usual" scenario by the year 2025 will represent a *per capita* consumption five times greater than that at present times.

Fig. 1 - Energy use *per capita* and *per dollar* of GDP 1970-2000 *(Index 1970 = 1)*

Adapted from: www.eia.doe.gov/oiaf/aeo/early release

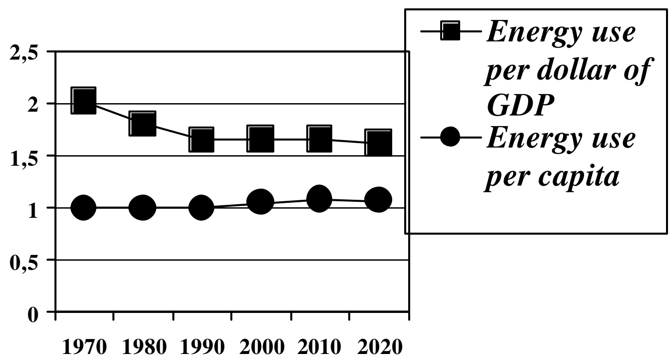

Table 4. - Mexican energy production and consumption scenarios in 2025

(Data from[4])

SOURCES	1994 67GJ/capita 5,763PJ	B.A.U. 350GJ/capita 45,500 PJ	CONSERVATION 200GJ/capita 26,00 PJ	SUSTAINABLE 100 GJ/capita 13,000 PJ
Non-Renewables	89.9 %	97.8 %	78.0 %	68.0 %
Renewables	10.1%	2.2%	22.0%	32.0%

GJ = 10^9 Joules, PJ = 10^{15} Joules

Renewable energy sources must become an increasingly important factor in the energy mixes that all nations, but specially developing ones, will have to adopt if they want to approach a better balance between development and ecological sustainability of the Earth's life supporting systems. Wind and solar cells may play an increasingly major player in a more ecologically minded energy economy. India is already a leader in wind-generated electricity with close to 900 megawatts produced by this means. China is starting to develop wind-farms in an important manner, stimulated by the lowering of costs of wind-driven electricity generators.

This and other sources such as solar panels and rationally managed biomass-generated electricity schemes should become major players in solving the energy demands of developing countries, but minimizing the environmental effects of their operation.

GLOBAL ETHICS AND THE FATE OF HUMAN SPECIES

We are still very much left with the question of which would be the social implications if humanity was presented with an inexhaustible source of clean energy, with no major direct environmental or health impacts. Would this induce an ever more consumer-oriented society whose only values would be the achievement and accumulation of material goods and well being? And what about its possible demographic consequences and their environmental impacts?

Paul Ehrlich [5], who has written extensively on the conflicts between human population growth, over-consumption by developed nations of energy and natural resources and the resulting environmental impact, describes what he and his collaborators term the "human dilemma", consisting in how to transform social attitudes from attaining the "best standards of comfort" and its consequent dramatic inequalities at the global level, to dignified standards of living, based not on material accumulation but on personal and spiritual achievements in an atmosphere of greater social equality.

Paradoxically, the social response to this problem is virtually inexistent. No one seems to be concerned about the profound consequences that global warming has, less so in developing countries. There is a feeling among scientists concerned with the issue that the more informed talk there is about global warming, the less is the level of public concern about it. Those of us in the field of global environmental studies feel the frustration of how to adequately convey the seriousness of the problem without crossing a thin line, which results in transmitting a feeling of hopelessness, which in turn generates social indifference. So far we have failed to succeed, despite very notable events such as the Rio and Kyoto Conferences, which have brought the temporary attention of the governments of most of the world's countries, but precious little concrete actions. Despite agreements reached at Kyoto in 1997, on a broad set of targets and timetables for a reduction of greenhouse gas emissions, it now seems evident that most industrialized countries will not meet these targets.

It is no surprise that a good deal of this lack of concern is linked to the idea that acting to reduce global problems, such as atmosphere warming, affects the economy of the countries and constitutes a menace to established or desired levels of comfort and well-being. That the effects (if any, in the mind of sceptics) do not affect present day populations. The feeling that the problem is geographically and temporarily displaced from specific societies is a formidable barrier to break. However, at the same time it constitutes the most serious ethical dilemma for our generation, not only for those that will follow us, but for those present now in extremely unprivileged conditions. In the view of many ethicist and philosophers, the spatial location of present generations or the temporal location, ignorance of, and the contingency of future generations cannot justify denying our ethical responsibilities to people in the future. It is meaningful to regard our duties to future generations. Our actions today should be restricted by ethical obligations that we owe to people of the future.

As a result of the dramatically uneven distribution of energy and the disparate rates of its consumption, the World Energy Council at its 17th World Congress (1998) concluded that the number one priority in sustainable energy development today for all decision-makers in all countries is to extend access to commercial energy services to the people who do not now have it and to those who will come into the world in the next two decades, largely in developing countries. Otherwise, their opportunity for education, good health and individual dignity will be in doubt. Meeting the energy requirements of these people will be the first test of the sustainability of the world's energy development path [6].

Maurice Strong [7], a key role player in the existence of the 1992 Rio conference, is convinced "that the new millennium we are entering will decide the fate of the human species. Our fate is literally in our hands". The major difference between the responsibility held by our generation and that of past generations, is that now, as never before, we understand clearly the possible impact of our action on the life prospects of future generations and have the tools and information to act.

For most people in the Western culture, especially for policy-makers, science and technology offer the only hope for solving environmental problems, because they often involve very technical matters. Due to the fact that science normally offers objective and factual answers, in an area dominated by diverse interests, it seems an obvious candidate to recur to in search of help about environmental concerns .

However, environmental challenges are neither exclusively nor primarily problems in the realm of science and technology. Environmental issues raise fundamental questions about what we as human beings value, the kind of beings we are, the kinds of lives we should live, our place in nature, and the kind of world in which we might flourish [8]. Environmental problems require answers from questions that are essentially ethical and philosophical.

The only serious alternative is to recognize that both science and ethics are essential if we hope to make meaningful progress in meeting the environmental challenges confronting us [8]. We must remember that "science without ethics is blind, and ethics without science is empty".

Many environmental scientists are convinced that it is possible to break out of this seemingly vicious circle, by showing that there is a way to reduce the effects of energy use by the application of more environmentally sensitive technologies. But it is also quite clear that this will not be enough on its own, if a stricter regulation of population size-mostly in developing regions - and specially a very different behaviour towards energy demands on the part of affluent societies, is not exercised. The latter means, in many cases, a serious change in the absurd levels of comfort enjoyed in many developed countries, as well as more sober expectations of the future standards of well-being and comfort sought by developing nations. These two issues represent themselves also ethical choices on the part of societies.

In consequence, it makes little sense just to look at the way in which developing countries must transform their technologies and sources of energy for the future (which they obviously should do) as the technological fix to the environmental problems we are facing globally. It makes even less sense in discussing how they will have to draw limits to their needs and expectations of development, in isolation of what is, and should be, occurring in the rest of the world.

The 1987 report of the UNCED *Our common Future* stated that the possibilities of human survival and well-being depended on "elevating sustainable development to a global ethics". If we are morally serious, it will be necessary to define to what extent the concept of sustainable development constitutes a real ethics for society. It will be necessary to define what kind of an ethics it is. What do we want to have in a state of sustainability and what kind of economic growth is sought and what ecological, social, political and personal values it serves. Equally "how it reconciles the moral claims of human freedom, equality and community with our obligations to individual species and ecosystems" [9]. Ethics, in this context, should be considered as a reflection about morality and moral problems, where these are subjected to a rigorous intellectual scrutiny.

An important reason for the crucial task that ethics should perform on issues of development for the future is its role in clarifying values at stake in policy decisions and giving moral reasons for alternative courses of action. Environmental and development issues are loaded with moral implications that need to be understood and carefully weighed before intelligent choices are made. It should help resolve value conflicts that thwart ecological conservation and development projects [9]. A new social paradigm should be developed with the help of ethics that will promote sustainable development with the maintenance of cultural diversity, social justice and equitability. This new “social paradigm” must constitute a collection of norms, beliefs, values and habits that form the world view most commonly held within a culture, which is transmitted from generation to generation [10]. This new social paradigm should elevate sustainable development to a global ethics that recognizes and promotes the mutuality of ecological and social values in specific societies [9].

Many of the problems caused by development - as we have envisaged it until now - are the result of our vision of nature from “outside”, as if we human beings were onlookers on a bountiful realm of goods and processes - on which we thoroughly depend for our existence, and which we very poorly understand. We are in need of a new vision. One that places us as a species, product of the process of hundreds of millions of years of evolution, which has conformed nature as we know it now. We must start thinking of a future for ourselves in this Planet not as individuals, societies, nations or regions, but as one specific biological entity: *Homo sapiens*. We should look for the well-being of all the individuals which conforms our species and for the conditions that will maximize the potential of the development of each individual’s creativity preserving the diversity that each genetic make-up represents.

The moral significance of the ethics of sustainable development lies not in the theoretical and specialized concerns of specialists, but in a vision of a new way of life that is comprehensible and accessible to all human beings [11]. But equally, or even more important than its moral significance, is that its practicability - the effect that it may have on changing human behaviours - depends totally on how to convert theoretical principles and concepts into politically and socially accepted norms of action. This, no doubt, is the greatest challenge for those ethicists, ecologists and other scientists who are convinced of the need of this new social paradigm.

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