UNITED NATIONS ENVIRONMENT PROGRAMME

NEW AND RENEWABLE SOURCES OF ENERGY

The Environmental Dimension

A report to the United Nations Conference
on New and Renewable Sources of Energy
Nairobi, 10—21 August 1981

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PREFACE

The 1970s brought into focus two global issues that are of primary importance in determining future world development, namely "Environment" and "Energy". In the early years of the decade, the environmental movement was approaching its peak and an "energy crisis" was in the making. The emergence of the two issues at the same time was not mere coincidence. As the last decade has shown, both issues are closely related, and have marked socio-economic as well as political dimensions.

The general realization of the finite nature of fossil fuel resources has caused a re-examination of the possibility of using those energy resources which are of a non-depleting nature, and are therefore considered renewable. These energy sources are becoming increasingly important both in developed and in developing countries. In the former strategies for the exploitation of such sources constitute a part of recent policies which aim at reducing the dependence on fossil fuel. In the developing countries, particularly those short of fossil fuel resources, the renewable sources of energy show promise of meeting some of the future energy needs, especially of rural areas. Without strong rural development programmes based on decentralized energy sources, urban migration will become torrential, exacerbating the already dire urban problems brought into focus at the United Nations Conference on Human Settlements in 1976. Similarly, the United Nations Conference on Desertification convened in 1977 emphasized the importance of using locally available renewable sources of energy to reduce excessive wood cutting in arid and semi-arid areas, which is one of the most important causes of desertification. The importance of renewable sources of energy has been recently brought into focus by the decision of the General Assembly of the United Nations to convene a United Nations Conference on New and Renewable Sources of Energy in Nairobi in August, 1981.

At local, national and in some cases regional levels, the environmental aspects of energy production and use have become the subject of wide-ranging debate. Environmental awareness and anti-pollution campaigns have affected the formulation of energy policies in many countries, and it has recently been realized that nations are not isolated in this respect; the actions of one country may affect the environment in a neighbouring one. Nowadays, energy policy decisions are dictated less by technological than by social, environmental and political factors.

One of the tasks assigned to the Governing Council of the United Nations Environment Programme by the General Assembly of the United Nations in its resolution 2997 (XXVII) of 15 December 1972 is to:

> "keep under review the world environmental situation in order to ensure that emerging environmental problems of wide international significance receive appropriate and adequate consideration."

In this respect, the United Nations Environment Programme has embarked on a number of in-depth reviews of the environmental aspects of production and use of all sources of energy. The present report summarizes the findings of the study on renewable sources of energy and outlines the activities of the United Nations Environment Programme in the area of New and Renewable Sources of Energy.

I. OVERVIEW

Of the many environmental impacts associated with any energy technology, some would be substantial and others small, some important and others of little consequence, some of short duration and others with long term effects, some might be adverse and others beneficial and they might occur in different geographic areas and might affect different communities in different ways. A distinction should be made between the assessment of the nature, scale and geographic distribution of the impact, and the evaluation which is concerned with its value or importance. For many environmental changes which are identified as impacts, the state of knowledge and technology will often only permit a qualitative assessment. Only in a few cases it is possible to evaluate an impact quantitatively. Decisions must utlimately be made on the basis of combination of cost/benefit analyses, other quantified inputs and qualitative information.

Discussion of the environmental impacts of various energy strategies has, in the past, tended to focus on short-term aspects, such as occupational and public health and direct impacts on the physical environment, than on the long-term socio-economic and environmental consequences. However, there is now a growing disposition to analyze these long-term impacts which may range from those for which substantial data exist and around which there is a fair degree of certainty as to the risks involved, to those which are rather speculative in nature and for which very little data are available.

The biosphere consists of different organisms, plants and animal life supported by a number of physical characteristics such as topography, soils, climate, air, water supply and drainage. For a given development, these physical characteristics and hence the biosphere may be affected. Whenever pollutants are released, the analysis of the environmental impact of these pollutants requires the knowledge of the:

(a) quantity and types of pollutants released;
(b) dispersion of these pollutants in the environment;
(c) ecological pathways followed by the pollutants;
(d) relationships between the pollutants and the damage to man and his environment;
(e) the extent of the damage including its cost (where it is possible to make this assessment).

Pollution is the introduction by man into the environment of substances and/or energy (so-called pollutants) liable to cause hazards to human health, harm to living resources and ecological systems, damage to structures or amenity, or interference with legitimate uses of the environment.

The total impact of some pollutants may depend on positive or negative synergistic effects. Although standards have been formulated for "acceptable" levels of several pollutants, it is prudent to assume that for exposure to many pollutants there is a controversy as regards to the presence of a threshold and that effects can occur at very low exposures. A further feature is that many pollutants may remain in the environment (and accessible to the food chain) long after the action releasing them has been discontinued. Attempts to assess the long-term impacts of these pollutants, although difficult, should be made taking into consideration the different pathways, biogeochemical cycles and fate of these substances in the environment.

The assessment of the environmental impacts resulting from the production and use of energy is important in relation to policy-making and decisions about energy options or "mixes" to be developed. The conservation of the natural environment is essential to the maintenance and regulation of the food, air and water cycles on which human life depends and to socio-economic development. It should be emphasized that environmental objectives are neither inconsistent with energy policy, nor impose constraints upon it: a balance can be maintained between the need to preserve and improve the quality of the environment and the socio-economic goals and needs that depend on the availability of energy. To state that energy policy questions are, nowadays, social, environmental and political as well as technical is to state the obvious.

The resource base of "new" and renewable sources of energy is extremely large. However, with the present state of technology, it is difficult to estimate how much of the resource base can be technically and economically exploited. There is no doubt that accelerated research and development will lead to a reliable estimate of the potential of new and renewable sources of energy within the overall future world energy supply systems.

New and renewable sources of energy - like any other source of energy - may have a host of interrelated environmental effects within nations, within regions, or on an even wider international scale. Among these, questions of the availability and allocation of resources are likely to play as important a role as pollution problems proper. Land and water use, emissions and their impact on ecosystems and human health are but examples of the problems to be encountered. Although the environmental impacts of some renewable sources of energy are known, there are still many inadequacies in our knowledge that call for detailed assessment and evaluation. Comprehensive environmental impact assessment should constitute an integral part of the planning and development of energy policies to avoid, from the onset, wastage of resources and pollution. This is more appropriate and certainly more efficient than redressing environmental degradation after it occurs.

The Environmental Impacts of New and Renewable Sources of Energy * :

Geothermal Energy:

World Geothermal Resource Base = 12.6 X 10^{26} J
= 4.6 X 10^{16} tonne coal

Present World Geothermal Electrical Generating Capacity = 2472 MW(e)

Present World Low-temperature Geothermal Energy (non-electrical applications) = 8008 MW(t)

Geothermal scenarios by the year 2000:

Electricity Generation = 50,000 MW(e)
Non-electrical Applications = 100,000 MW(t)

The utilization of geothermal energy for the production of electricity and the supply of domestic and industrial heat dates from the early years of the twentieth century. Since geothermal energy must be utilized or converted in the immediate vicinity of the resource to prevent excessive heat loss, the entire fuel cycle, from resource extraction to transmission, is located at one site. This does not only reduce the costs and risks of the environmental impacts of the fuel cycle but also facilitates environmental protection measures (in contrast; the different stages of the coal, oil, natural gas and nuclear fuel cycles are normally located at widely separated sites). Unlike fossil fuel or nuclear power production, geothermal energy is not a technology that requires massive infrastructure of facilities and equipment or large amounts of energy input.

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* For details, see : UNEP, The Environmental Impacts of Production and Use of Energy. Study Director: E.El-Hinnawi, Tycooly International, Dublin (1981); El-Hinnawi, E. and Asit K. Biswas (Editors), Renewable Sources of Energy and The Environment, Tycooly International, Dublin (1981).

On the other hand, geothermal energy has a number of adverse effects on land, air and water. These effects are site specific and vary according to the geochemical properties of the hydrothermal reservoir and the exploitation history of the resource. Possible impacts on land include: land use and land subsidence resulting from the withdrawal of geothermal fluids from the reservoir. The latter problem can possibly be alleviated or avoided by reinjection of geothermal fluids into deep wells following power production. Reinjection is also considered an important factor in increasing the productive life of a geothermal field, as it is considered a "recycling" of the geothermal waste water through the reservoir.

The major sources of air pollutants emitted during geothermal power production are direct releases of geothermal steam during all stages of development and releases of non-condensable gases during plant operation. The types of pollutants likely to result from geothermal power development are primarily determined by the chemical composition of the geothermal fluid. Both the total quantity of gases in the fluid and the relative concentration of their constituents depend on the geochemistry of the underground reservoir. Geothermal steam contains carbon dioxide, hydrogen sulphide, ammonia, methane, hydrogen, nitrogen and boric acid. In steam-dominated fields (for example, The Geysers and Larderello), the discharged steam composition corresponds to that at depth. However, in high temperature water-dominated fields the proportion of gas in the steam depends on the extent to which steam has flashed from the original high-temperature water. The gases (except ammonia) are predominantly concentrated in the steam phase and the gas/steam ratio decreases with increasing steam proportion in the discharge. Several geothermal areas are situated in districts with known mercury mineralization (e.g., The Geysers, California; and Ngawha, New Zealand)and higher than normal, regional concentrations of mercury occur in the air. The levels of mercury are, however, unlikely to present a health hazard, although it has been considered that prolonged exposure to atmospheric levels of mercury in excess of 0.1 $\mu g/m^3$ may be harmful.

The quality of the geothermal water - its physical and chemical characteristics - varies widely. While some geothermal hot waters contain relatively few pollutants, most contain a relatively large amount of dissolved solids and heavy metals because the high temperatures of the brines increase the dissolution rate of solids and heavy metals in the rock. The most common type of geothermal water is a sodium, potassium, chloride solution containing appreciable concentrations of silica, boron, sulphur, ammonia, fluoride, and various trace metals. Moderate temperature waters (up to 130°C) used for various domestic, commercial and agricultural heating purposes do not present unique problems and should be considered as any other waste water whose environmental significance is related to its salinity and chemical composition. Reinjection is the favoured means of waste water disposal for most geothermal developments. However, it cannot be described yet as well-established technology, except for the simple case of steam condensate reinjection where relatively small volumes of water are involved, and the solutions are dilute. In an area where water supplies are drawn from underground aquifers it is important to have a knowledge of the local hydrology and to carefully monitor any effects arising from the injected geothermal waters.

Solar Energy:

Annual Solar Radiation Received at the surface of the Earth = 1.2×10^{17} *W*
= *20,000 times present annual world Energy consumption*

Daily average solar Insolation = *9-25 MJ/m²*

Solar energy has been used in many areas for centuries, but mainly in a primitive way (for example, for crop drying in rural areas). Several solar devices for heating water, greenhouses, etc. have been developed and although at present the use of solar energy is still limited, extensive research and development programmes are under way in many countries to harness solar radiation efficiently for a broad number of applications. These range from heating and cooling of buildings, water heating, desalination, refrigeration, solar drying, telecommunications, irrigation, electricity generation to ovens for high-temperature materials processing.

Solar energy devices (whether for electricity generation or for non-electric applications) have a number of environmental impacts. Decentralized small units (e.g. water heaters, solar dryers, cookers, photovoltaic-operated equipment, solar refrigeration, space heating and cooling ...etc.) do not only reduce the demand for fossil fuels leading to the conservation of such non-renewable energy sources, but also would lead to the reduction of the bulk of pollutants emitted by burning such fuels. In industrialized countries where, for example, space heating takes up to 20% of the energy budget of the country, the use of solar heating can drastically reduce the dependence on oil products for such purposes. In the developing countries, the use of decentralized solar devices can lead to substantial improvements in the quality of life in rural and remote areas. It can minimize the consumption of the generally subsidized kerosene and the dependence on fuelwood and other non-commercial energy sources, the use of which has created unacceptable environmental impacts. It should be noted that although several systems for solar energy utilization are now commercially available, there is still need to demonstrate their feasibility for wide-scale application. Several governments, regional and international bodies have recently embarked on different demonstration projects related to different applications of solar energy; such projects will contribute to our knowledge of the technology, economic, social and environmental aspects of these energy systems.

The use of solar energy for water heating for domestic or industrial purposes is environmentally benign. The same is true for space heating and cooling. No land is required since roof-top solar collectors are used, there are no emissions or wastes to be disposed of since the solar thermal systems are closed systems. Accidental leakages from the systems are not hazardous if water is used as the heat-transfer medium. If organic liquids are used, certain precautions should be taken to avoid the undesirable effects of these liquids in case of leakages.

Solar thermal power plants do not emit gaseous, liquid or solid effluents like fossil fuel or nuclear power plants. They are relatively "neutral" as far as excess heat rejection is concerned, i.e., the heat left at the site is similar to what would have been deposited if no plants were there. The heliostat field associated with a solar thermal power plant could produce localized changes in the net albedo, energy balance, moisture-balance, low-level wind-flow patterns, and air/surface temperatures. The impact of such changes on microclimate within and immediately surrounding the solar thermal power plant remains to be adequately assessed.

It is commonly stated that a major draw-back of solar power plants is the extensive land requirement. However, the amount of land required for a solar plant is comparable to what is required by the system which provides electricity from fossil fuels or nuclear power. The area requirement for 1 MW(e)y of solar thermal power plant over its lifetime is about 2000 m^2; that of coal, for example, is about 3000 m^2. While the area requirements are comparable in the two cases, operation of the solar unit would actually involve a more benign use of the land. However, it is claimed that heliostat fields might disrupt the ecology of the area, especially if located in desert areas. Although this might be the case in certain locations, the location of heliostat fields in some deserts (e.g. in North Africa) would have beneficial effects by creating centres of activities in such barren areas, attracting, for example, nomads to settle down near such centres.

Wind Power:

Global Wind Resource Base
= 1200 X 10^{12} W

Future Wind Energy scenarios:

year	*Installed capacity (kw)*
1990	*1 X 10^7 (Output 3 X 10^{10} kwh/y)*
2000	*2 X 10^8 (Output 9 X 10^{11} kwh/y)*

Environmental concern about wind energy involves such factors as the risk of accidents, noise, interference with telecommunications and the possibility of local climatic alterations. Since the ground area requirements are small and the land surrounding the windmills can be used with few restrictions, the space problem is mainly one of aesthetics. The setting up of windmill arrays in mechanically cultivated fields can cause a certain amount of interference due to the presence of towers, guy wires, etc. This effect is reduced if the land is used for grazing purposes only. In the case of wooded areas the tree cover could seriously interfere with the operation of the windmills and may completely preclude their use altogether. All energy transmission systems leading from windmill arrays established in agricultural areas will require overhead installation to avoid interference with traditional agricultural operations. The installation of large windmill arrays (windmill parks) in areas normally inhabited by wildlife or along the traditional migratory paths of wild fowl, birds could hinder or harm the wildlife.

The large scale generation of electricity through windmill arrays can have some modulating effects on telecommunications etc. Studies of TV interference at a single wind energy converter has indicated the need to place aerials at distances of 5-10 rotor diameters. Catastrophic failure of wind energy converters has occurred. Considering that very large wind systems will most likely be installed in areas with little population, the chances for loss of human life would indeed be small. Restriction of land surrounding windmill parks could be made to guarantee safe conditions. Also, safety inspections of large systems could be made mandatory.

Energy from the Sea:

Wave power is by no means a new concept. It is estimated that since 1856 over 350 patents were granted for wave power utilization by 1973. Today wave energy is only used on a small scale to power buoys; the average power output of these systems ranges from 70 to 120 W.

Total Wave power (Resource base)
= 2.7×10^{12} W annually

Because there are no large-scale wave power stations existing today it is difficult to assess the environmental effects of harnessing this energy source. Wave power plants will produce no thermal discharges or emissions or cause changes in water salinity or require fresh water for operation. The most direct environmental impact is to calm the sea, since they will act as efficient wave breakers. This has beneficial effects in several locations near harbours offering safe anchorage in times of storms, and/or protecting shorelines from erosion. However, the calming of the sea might have adverse biological effects because of the absence of waves and associated mixing of the upper layers of the sea. On the other hand, wave energy plants are likely to enhance the growth of many marine organisms by providing a more protected habitat. Large scale wave energy systems may influence climate, because they will interfere with the wind-driven oceanic circulation and with sea-atmosphere transfer processes.

Tidal power can be harnessed at specific sites where the tidal amplitude is several metres and where the coastal topography is such as to allow the impoundment of a substantial amount of water with a manageable volume of civil works. Tidal energy may be pollution

Present Estimated World Tidal Power Potential = 6×10^{10} W

free, in that it does not add pollutants either to the atmosphere or to the water, but it will change the ecology of its tidal basin and, to some degree, may also affect the tidal regime on the sea side of the development. The extent of this effect would of course depend on the magnitude of the tidal development. Some of the detrimental effects on eco-systems attributable to river hydro plants would be applicable also to tidal power plants.

The concept that the temperature difference between the surface and the deep waters of the sea could be used as a source of energy dates back to about a century. The first pilot scale plant was built by Claude off the coast of Cuba in the late 1920s in which warm sea water was used as the working fluid. Recently several plants have been designed for ocean thermal energy conversion, known as OTEC plants. The most important location of the sea thermal resource is, roughly, the 2000 km-wide area around the equator between the Tropic of Capricorn and the Tropic of Cancer. In that area deep sea water (750 to 1000 m) may be from 15^{o} to 25^{o}C colder than surface water.

The environmental problems posed by the extensive use of ocean thermal power systems range from questions dealing with the biological and ecological aspects of antifouling agents, primarily used for the evaporators, to those dealing with the ecological and environmental impacts due to changes in salinity and thermal redistribution.
A positive effect which has been postulated is that the movement of vast quantities of water from the nutrient rich cold waters could be used for large scale food production. However, because of the huge volumes of water involved, there is a potential danger of reduced surface temperature which may have local and global weather effects. The presence of numerous moored OTEC plants with kilometres of electric cable suspended in the ocean may interfere with shipping (or other uses of the sea) and may introduce a risk element to OTEC installations both from submarines and surface vessels.

Hydro-power:

World Hydro-power Potential

	Potential available 95% of time (10^3 kW)	Potential output 95% of time (10^6 kWh/y)	Present install-ed capa-city (10^3 kW)	Current annual produc-tion (10^6kWh/y)	Percent developed potential (4)/(2)X100
	(1)	(2)	(3)	(4)	(5)
Africa	145 218	1 161 741	11437	49663	4.3
Asia	139 288	1 114 305	59773	245096	22.0
Europe (incl. USSR)	102 961	827 676	177797	620676	75.0
N. America	72 135	577 086	111402	434035	75.2
Latin America	81 221	649 763	38582	176845	27.2
Oceania	12 987	103 897	9578	31669	30.5
World Total	553 810	4 434 468	408569	1557984	35.1

Hydro-power is an important renewable source of energy, and should constitute an integral part of the overall water resource development. It is a catalyst in socio-economic development, particularly in rural areas of developing countries and its economic justification is improving because of its "inflation proof" characteristics and its long life and low maintenance costs.

Hydro-electricity generation has a number of environmental impacts. No dam can be built and no lake can be created without environmental costs and benefits of some kind. A dam becomes a dominant factor in the hydrological regime, and sets in motion a series of impacts on physical, biological and socio-cultural systems. The many consequences on the environment of the dam and the lake behind it appear to be factors in common regardless of the dam's geographical location. The environmental side-effects of dam construction are generally divided into two categories: (a) the local effects and the reactions within the area of the man-made lake; (b) the downstream effects resulting from a change in the hydraulic regime. Both categories have their physical, biological and socio-economic elements.

Although it is designed to store water, a man-made lake immediately begins to store sediments carried by the stream. The amount of sediments deposited in a given reservoir depends on the amount of sediments delivered to it and on the reservoir's ability to retain the sediments. The effects of sediments deposition in reservoirs are evidenced in many ways but perhaps most significantly in terms of the reservoir's ability to perform its intended functions. Water resource function most commonly served by reservoirs include water supply, irrigation, flood control, hydro-electric power, navigation, recreation ... etc. To the extent that sediments distract from the services provided or expected from a reservoir, it is a liability expressible as the lesser of either (a) the cost of services foregone because of the sediments or (b) the cost required to remove the sediments from the reservoir or to keep it out in the first place. Depletion of storage capacity is but one of the upstream effects of reservoir sedimentation. On the other hand, as a result of the siltation in the reservoir, clear water flowing downstream cause channel degradation and stream bank erosion. Changes in quality and quantity of sediments downstream are believed to affect agriculture and fish production in many ways.

Man-made lakes generally alter not only the streamflow regime but also the water balance (and the hydrological cycle). These effects may be of particular significance in arid and semi-arid regions. In some areas, where the premeability of the substrate is high, vast amounts of water are lost by seepage from the reservoir. On the positive side, this seepage has led to changes in volume and direction of ground water flow, facilitating reclamation of low-lying arid lands at considerable distances from the lake. On the negative side, however, the increase in the water table downstream has led to the production of bog effects and in some cases salinization that adversely affects the agricultural use of the soils.

The construction of a dam and the creation of the associated reservoir has a number of impacts on terrestrial and aquatic biota which are of four main kinds: (a) those of short life-span and frequent population turnover (e.g., nutrient-cycling bacteria and many algae), (b) those of intermediate life-span and turnover (e.g. cereal crop plants, some small fish), (c) those of long life-span and slow population turnover (e.g. perennial plants and large aquatic or terrestrial animals or domestic livestock), and (d) people. The impacts of dam construction on these ecosystems should be assessed in detail and the actual and potential benefits of not undertaking versus undertaking the scheme should be determined.

Once the impoundment has been completed, the succession of plant growth colonizing the shorelines, and at times even the body of the lake, will influence the incidence and development of vector-borne diseases. Excessive weed or algal growth downstream as a result of the biogeochemical changes in the water quality of the river or due to changes in the irrigation system (e.g. from basin to perennial) will also influence the incidence of such diseases. Not only will such vegetation promote the breeding of schistosome-bearing snails and malaria mosquitoes, but it could also encourage the development of the filariasis vectors.

When a man-made lake is created, the members of the lake basin population are displaced, crowded or supplemented by new migrants. Within the lake basin the human population can be divided into four general categories, of which the first two pose the most problems. These categories are (a) those who must relocate because their homes and fields will be partially or totally inundated by the reservoir (the relocatees), (b) those among whom most of the relocatees must be resettled (the hosts), (c) those lake basin inhabitants who are neither relocatees nor hosts and (d) immigrants who move into the lake basin and seek new opportunities that accompany dam construction and reservoir creation. Most of the population displacement exercises have created several problems. Inadequate planning, insufficent budget, incomplete execution of plans ...etc. have all contributed to the failure of resettlement plans.

On the other hand the building of dams and the creation of reservoirs have a number of socio-economic benefits: better water management and development of irrigation systems to increase agricultural land and production of power needed to accelerate industrialization and socio-economic development. The lake itself provides opportunities for a number of socio-economic activities ranging from agriculture on the sides of the lakes, to fisheries, tourism and the development of small industries.

Energy From Biomass:

Fuelwood and Charcoal:

The magnitude of fuelwood consumption in the world, especially in the developing countries, as well as its significance in the everyday life of well over two billion people, was not realized until recently. Many developing countries depend upon wood as their major source of fuel. For example, in Kenya where 90% of the population live in rural areas, they depend almost exclusively on fuelwood as their primary source of energy (80% is used for cooking and the balance mainly for heating). In Zambia, fuelwood and charcoal constitute about 88% of sources of energy used in rural and urban households.

Fuelwood is also the principle source of energy for cooking and other domestic uses in Sri Lanka, Nepal, Thailand and several other countries, and it is an important fuel in the rural areas of all African and Asian countries. In these areas, where wood is readily available, nearly 95% of households use it as a primary source of energy; the per capita consumption varies from 1.3 m^3 to 2.3 m^3/y, with an average of 1.5 m^3/y. About 50% of the wood consumed as fuel is used for cooking; 30% for domestic heating and the remaining 20% for processing agricultural products, industry, etc.

World Forests and Woodlands

Tropical Forests	*1460*	*million*	*ha*
Sub-tropical forests	*220*	"	"
Open Savannah	*1000*	"	"
Temperate Forests	*450*	"	"
Boreal Forests	*670*	"	"

The annual increment from forests and woodlands has been estimated to be about 6,600 million m^3 (according to FAO statistics, the total world consumption of roundwood in 1978 was about 2600 million m^3, about 47% of which was used as fuelwood and charcoal. However, this figure is underestimated, since it does not take into account wood and charcoal which is self-collected (or produced) - the so-called non-commercial. A figure in the range of 5000 million m^3 may be more plausible). However, on a world-wide basis all the increment is not being removed, and much of this unremoved increment is in the inaccessible northern coniferous forests of Alaska, Canada and the U.S.S.R. This has led to an over-exploitation of the forests in certain regions to meet the increasing demand for wood, destroying thereby the resource base. Deforestation of tropical forests has been estimated to occur at a rate of 10-12 million ha/y. Most of this deforestation occurs (and will continue to occur) in the developing countries, whose humid tropical forests and open woodlands are steadily being felled and converted to farmland and pasture. This trend is impelled by several forces: the expansion of agricultural frontiers into forested areas in order to supply food as population increase; the demand for fuelwood and charcoal; the demand for tropical forest products by industrialized nations; and the demand within the developing countries for paper and other forest-derived products as incomes rise. With the present rate of deforestation in the developing regions, where fuelwood is most needed (the demand will increase by the year 2000), situations have evolved where fuelwood has become quite scarce (UN Conference on New and Renewable Sources of Energy, A/CONF.100/PC/34, 1981).

Fuelwood comes overwhelmingly from local sources, and this puts growing pressure on the trees, bushes and shrubs near to centres of population. Long before the demand for fuelwood leads to complete destruction of the tree cover, it can have a markedly degrading environmental effect. Excessive pruning of the branches may reduce a tree's capacity for growth; removal of the more easily-felled younger trees may reduce the regenerative ability of the forest; excessive opening of the canopy through the removal of too many trees can render the forest susceptible to damage from wind and sun and can affect wildlife generations; the removal of all residues, even to the point in some areas of sweeping up the leaves, removes the nutrients that should return to the soil to maintain its fertility; removal of stumps, bushes and shrubs can destroy much of what remains of the soil's protective cover and binding structure. And eventually, the whole forest may be felled and disappear.

Recently, it has become evident that an additional input of non-fossil excess carbon dioxide into atmosphere, due to forest cutting, forest burning, soil management practices, etc., is of the same order of magnitude as the input of fossil fuel CO_2 (estimated at 5×10^{15} g C/y). About half of this quantity of carbon dioxide is removed from the atmosphere through different geochemical cycles, and the net contribution of non-fossil fuel sources to the carbon dioxide budget of the atmosphere is not accurately known but considered a substantial one. The increase in atmospheric CO_2 will lead to an increase in the earth's surface temperature (through the greenhouse effect). Results from climate models suggest that a doubling of the CO_2 concentration would give an increase in the global average earth surface temperature of 1.5-3^{o}C. Although the consequences of such an increase are not accurately known, it is believed that it could have far reaching impacts on natural ecosystems as well as human activities.

The direct combustion of fuelwood is not without potential hazards. Besides home fires and burns, the combustion of fuelwood results in emissions consisting mainly of particulates, condensible organic compounds, carbon monoxide and polycyclic organic matter (POM). Such emissions could cause respiratory diseases and cancer. In a recent study by the U.S. EPA it was found that smoke from wood-burning stoves and fireplaces contained 17 priority pollutants, 14 known carcinogens, 4 co-carcinogens, and 6 cilia-toxic agents. The EPA study found that emissions of carbon monoxide and POM are much higher for air-tight wood stoves than for open fireplaces. Although it is only recently that data have become available on emissions from wood stoves, the available data base and overall understanding is much less than might be desired considering the potential health impact of emissions from wood stoves.

Another important environmental aspect of fuelwood combustion is the great amount of energy wasted. Cooking on an open fire requires more than five times as much energy as on a kerosene stove. The commonly used cooking stoves in the developing countries have efficiencies of between 6 to 10% (i.e. from 90 to 94% of the total heat value of the fuelwood is wasted). Several attempts have been made to increase the efficiency of wood stoves. In Indonesia, the Singer type stove with an efficiency of 27% led to substantial savings in wood consumption. Other types of efficient stoves include the Indian Junagadh stove (30% efficiency), the Guatemala Lorena type (15-20% efficiency) and the New Nepali Chulo (about 20% efficiency). On improving stove efficiency, it should be taken into account that fire making in rural households is not intended only for cooking, but also for other purposes, for example, for drying of different products. Improving the cooking efficiency of the stoves should not detriment these other functions. It should be also noted that the successful introduction of simple wood burning stoves depends not only upon choice of technology and technical efficiency but also upon another basic consideration: the needs and preferences of stove users. An improved stove which is not culturally and socially acceptable will not be used. On the other hand, the findings in the U.S. EPA study, referred to above, that more efficient stoves tend to emit more POM and carbon monoxide emissions (the stove acts more like a wood gasifier or pyrolyzer, and produces increased amounts of these pollutants) call for a detailed assessment of the health implications of efficient stoves before they can be put into wide-scale application.

The bulk of the world's charcoal is produced from wood by technologically primitive means. Traditional earth kiln methods yield one tonne of charcoal from 12 m^3 of wood (8.6 tonne air dry wood). Modern industrial processes in commercial use are capable of producing charcoal from wood at yields close to the theoretical one which is 3.3 tonne of wood per tonne of charcoal product. Thus they are 2-3 times more efficient in their use of the wood than the traditional methods. World charcoal production has been estimated to be about 4.6×10^6 tonnes in 1978 (United Nations, 1979). However, it should be noted that this figure is based on information supplied by a limited number of countries; many countries do not have adequate information on charcoal production. In many developing countries much charcoal manufacture is carried out by itinerants working for only part of the year and keeping no records of what they produce and sell.

Charcoal offers a number of advantages over wood as a fuel. Charcoal is easier to transport, store and distribute, more efficient in burning, less polluting, and it has special advantages in some industrial uses. Charcoal has a higher calorific value than fuelwood, and is traditionally preferred for a number of domestic uses as well as industrial, mainly metallurgical and chemical. The environmental impacts of production of charcoal are essentially the same as those described above under fuelwood, from which the bulk of charcoal is obtained. However, the use of charcoal is less polluting than fuelwood. It is smokeless, an essential requirement for cooking and heating in closed places, with much less emissions of particulates and hydrocarbons. Without adequate ventilation carbon monoxide poisoning may, however, occur.

Fuelwood will continue to be a major source of energy in many rural areas of the developing countries at least until the year 2000. Although some measures are being taken to develop fuelwood resources, and to use them more efficiently, fuelwood shortages are going to become more severe and will inevitably spread to areas where the problem hardly existed before. Massive deforestation in the developing countries is undercutting the long-term potential for increased fuelwood production. Special efforts should, therefore, be made to institute adequate forest management practices to protect the resource base from over-exploitation and destruction. Reforestation programmes should be undertaken at a much faster rate than, hitherto, has been the case; to ensure the success of such programmes, public education and participation is a primary prerequisite that has to be taken into consideration. Furthermore, ways and means of increasing the efficiency of fuelwood utilization (direct combustion or conversion into charcoal and/or other products) should be developed and put into wide-scale application. Detailed assessment of the environmental and socio-economic impacts of fuelwood production and use should be undertaken to ensure an environmentally-sound management of the resource base and a more efficient use of fuelwood.

Biogas:

Composition of Biogas

Methane	*55-65%*
Carbon Dioxide	*35-45%*
Nitrogen	*0- 3%*
Hydrogen	*0- 1%*
Oxygen	*0- 1%*
H_2S	

The formation of biogas by the anaerobic digestion of animal and vegetable matter was first recognized and reported during the latter part of the 19th century. During the past 50 years, some countries in Europe and North America have built anaerobic digesters to treat their sewage and in many cases have used the resulting biogas "sewage gas" as a source of energy. Apart from a few scattered small biogas plants in some developing countries (e.g. in India, People's Republic of China) in the 1950's, the main thrust to develop biogas plants came in the late 1960's and early 1970's. In India more than 36000 biogas plants ("gobar" gas) were built up till 1975-76; now the figure reaches about 80,000, mostly small family scale plants. The largest number of biogas installations is in the People's Republic of China, where more than 8 million plants have been constructed; the largest number is in the province of Szechuan. Biogas plants have been installed in several other countries, e.g., in Pakistan, Nepal, Bangladesh, the Philippines, Thailand, Japan, Indonesia, Sri Lanka, Tanzania, Botswana, Ethiopia, Kenya, Somalia, Egypt, etc.

Many options exist for utilizing biogas. It can be used directly in gas-burning appliances for cooking, lighting and refrigeration or it can be used as fuel for internal combustion engines (after reduction of hydrogen sulphide content and converting the internal combustion engine to use biogas). Another possible use is the use of biogas for the production of electricity. Biogas is extensively used in India, the People's Republic of China, and several other countries for cooking and lighting. It is also used for running irrigation pumps and machinery and for electricity production. For example, biogas from sewage in Fushan (Guangzhou, China) is used to operate a power plant with a capacity of 630 kW.

The effluent and sludge remaining, after anaerobic digestion has taken place, is a rich and effective fertilizer. Anaerobic digestion conserves, in organic or ammonium nitrogen forms, practically all the nitrogen present in the material used. The sludge produced by anaerobic digestion is believed to have a fertilizer value greater than that of the original raw material (perhaps due to more concentration in relation to volume of material). It has no offensive odour when spread on land and rodents and flies are not attracted to the remaining solid or liquid residues. It is claimed that the use of biogas slurry as a fertilizer had led to an increase in the yield of some crops by 10 to 28% in the People's Republic of China and India as compared to the use of excreta. Experiments in the Philippines have shown that rice fertilized with commercial urea had an average yield of 6.5 tonne/ha whereas rice fertilized with manure sludge produced 8.3 tonne/ha. The effluents can be used also for growing algae that can be used as animal feed and input material to the digester; the water from the algae ponds can be used for fish farming.

The environmental impacts of production and use of biogas should be considered in the context of an "organic waste - biogas - bioproductivity" integrated system. Biogas technology provides a means of organic waste management that is beneficial. Not only agricultural and agro-industrial residues can be managed beneficially but also animal manure. This is particularly important in rural areas of the developing countries which lack adequate disposal systems. Manure is a major source of different parasites (e.g. schistosomes, hookworms, etc.), and anaerobic fermentation eliminates to a large extent these organisms. This could lead to effective reduction in the incidence of parasitic diseases in rural areas. However, detailed research work is needed to determine the behaviour of different pathogenic organisms in the fermentation process and the amounts remaining in the slurry. Biogas can provide a part of the energy needs of rural areas of developing countries. This will not only lead to accelerated development of such areas, but also to environmental protection through the appropriate management and recycling of organic wastes. The use of biogas can also reduce the demand for fuelwood and charcoal in different regions, leading to the conservation of wood resources and reduction of the process of desertification. Several schemes of the "organic waste - biogas - bioproductivity" integrated system have been experimented in some countries on a small scale or on a village level (for example, in China, the Philippines, India, etc.). The problems to be encountered in large-scale schemes are different from those encountered in small scale (or family-size) plants. These include land and water requirements; collection, storage and handling of manure and other wastes; handling of slurry; distribution systems of biogas, safety questions in relation to handling large quantities of biogas, etc. The detailed assessment of such issues is a prerequisite for the success of large-scale integrated biogas systems.

Gasohol:

Production of ethanol through fermentation can be accomplished in at least three ways: (a) directly using naturally available sugars such as sugarcane; (b) indirectly using carbohydrate or starch sources such as cassava; (c) in combination with acid hydrolysis or enzymatic hydrolysis of cellulose sources such as wood which produces sugar that can then be fermented. While alcohol production from sugarcane or cassava are familiar techniques, this is not generally so in the case of cellulose hydrolysis. Several pilot-scale studies are underway in several countries for the production of alcohol from biomass; production programmes have already started in some others, the largest so far is the Brazilian National Alcohol Programme.

Alcohol yield of selected crops

Crop	*Crop yield per ha/year (tonne)*	*Alcohol yield per ha (litre)*	*Alcohol yield 1/t*
Sugarcane (Brazil)	*54.2*	*3630*	*67.0*
Sweet Sorghum (US)	*46.5*	*3554*	*76.0*
Cassava (Brazil)	*11.9*	*2137*	*180.0*
Corn (US)	*5.7*	*2200*	*386.0*

Up to 20% ethanol can be blended with gasoline (Gasohol) without any changes in present-day internal combustion engines. Minor modifications, however, are required for engines running on 100% alcohol. Although ethanol has a lower calorific value than gasoline, ethanol has a higher density and a motor running on ethanol is 18% more powerful than a motor running on gasoline. When added to gasoline, alcohol increases the value of the octane rating. Instead of simply selling gasohol (90% gasoline and 10% alcohol) as a higher grade fuel, refineries could take advantage of this effect by producing a less refined gasoline to combine with alcohol. This would save oil at the refinery. Alcohol has the marked advantage of eliminating the use of lead anti-knock additives and of reducing the amount of hydrocarbon and nitrogen oxides emissions (aldehydes are, however, increased).

The production of alcohol is not without negative environmental impacts. Large areas of land should be allocated for growing sugarcane or cassava and in several countries such land may not be available or if available the question whether land should be used for energy farms (see later) or for food production will arise. In the fermentation process, large amounts of effluents are produced.

These include the raw material washwaters, stillage (bottom slop or waste residue drawn off the bottom of the first distillation column) and flegmass (bottom effluent from the second distillation column). Stillage is the most important effluent. It is generated at a rate which is 12 to 13 times in volume that of the alochol production. Because of its high content of soluble organics and inorganics, stillage has a high pollution potential if discarded into rivers. Since stillage normally does not contain pathogenic organisms or toxic compounds, recovery of its minerals and organics is a potentially attractive undertaking. It is technically feasible to convert stillage into marketable products such as fertilizers and feed additive or into methane as a supplementary energy source. Economics will ultimately determine the choice of stillage treatment process and the product form.

Energy Farms:

The term "energy farming" means the growing of biomass for its fuel value. Traditionally one thinks of energy farms as forests; recently, however, several alternatives have been suggested, for example, weeds, agricultural crops, grasses and algae (fresh-water and marine).

Several tropical trees are especially promising candidates for agroforestry projects. The leucaena tree (Leucaena acidophila) has received a great deal of attention recently as a source of fuel and food. Leucaena - known also as the Hawaiian giant, koa haole, or ipil-ipil, depending on the variety and its location - is a native of Mexico and is one of the world's fastest-growing trees. It can grow 20 m tall within six years. A leucaena plantation can annually provide up to 50 tonne of wood per hectare, five times the average of cultivated pines in temperate regions. Because of its spectacular growth potential, utility companies in Hawaii and the Philippines are planting leucaena as a fuel for some of their power plants. By early 1982, the national electrification company of the Philippines plans to establish 10,000 hectares of the tree to power a three-megawatt generating facility (the area is suited to provide wood for a 75 MW power plant). A Japanese company in the same country is planting 5000 hectares of leucaena it plans to convert to charcoal as fuel for a steel foundry. Leucaena, a member of the legume family is able to replenish the soil with nitrogen through the action of bacteria in root nodules and is thus particularly well suited to agro-forestry schemes. Among the many other trees now being used in reforestation schemes in the tropics, red kaliandra also deserves special mention. A native of Central America, the bush can reach 3.5 m in just nine months. Red kaliandra easily produces up to 33 tonne of wood per hectare every year and is often planted with food and ornamental plants in the vicinity of homes. Because of its fast growth, kaliandra competes with, and eventually suppresses, lalang, a tough perennial bunch grass that often invades and takes over cutover areas of Southeast Asia. In Indonesia, 34,000 hectares of red kaliandra have been established as a buffer zone around national forests to protect trees from fuelwood gatherers. Eucalyptus is the tree planted most widely throughout the world for fuelwood production. Several of the hundreds of species have adapted to a wide range of environments, from the cool highlands of the Andes to the warm, moist equatorial lowlands of Amazonia. Its ability to withstand drought, to regenerate profusely, and to grow luxuriantly within a short period are major reasons for its widespread dispersal. In Brazil, where yields average 12 tonne per hectare annually, eucalyptus is cultivated for charcoal and for methanol production.

Biomass production techniques are being optimized for warm season grasses, sugarcane, sweet sorghum and other species. Improvements in production, by way of higher yields and/or lower costs are being developed through closer plant spacing, improved fertilization and irrigation methods, and higher harvesting frequencies. Species improvements via genetic manipulation and nitrogen fixation are future options under study to increase the yield of biomass for energy.

Several problems are, however, inherent to energy farms; the most important are: land areas required, fertilizer and water requirements, pesticide requirements and pressures on soil productivity. The numerous programmes to divert agricultural resources to the production of fuel crops should be carefully evaluated. Care should be exercised not to encourage the production of energy crops at the expense of food production. Another problem that must be taken into consideration is the possibility of diversion of biomass (e.g. trees, once they have grown) into uses other than for energy (for example, extraction of cellulose for the chemical and/or textile industry, or for the paper industry), once the price has become attractive.

II. ACTIVITIES OF UNEP

The United Nations Environment Programme has been involved in different activities in the area of energy since its establishment in 1972. This has been in direct response to the recommendations of the United Nations Conference on the Human Environment (Stockholm, June 1972).

United Nations Conference on the Human Environment
Stockholm, 1972

Recommendation 57

It is recommended that the Secretary-General take steps to ensure proper collection, measurement and analysis of data relating to the environmental effects of energy use and production within appropriate monitoring systems:

(a) The design and operation of such networks should include, in particular, monitoring the environmental levels resulting from emission of carbon dioxide, sulphur dioxide, oxidants, nitrogen oxides (NO_x), heat and particulates, as well as those from releases of oil and radioactivity;

(b) In each case the objective is to learn more about the relationships between such levels and the effects on weather, human health, plant and animal life, and amenity values.

Recommendation 58

It is recommended that the Secretary-General take steps to give special attention to providing a mechanism for the exchange of information on energy :

(a) The rationalization and integration of resource management for energy will clearly require a solid understanding of the complexity of the problem and of the multiplicity of alternative solutions;

(b) Access to the large body of existing informat-ion should be facilitated:

(i) Data on the environmental consequences of different energy systems should be provided through an exchange of national experiences, studies, seminars, and other appropriate meetings;

(ii) A continually updated register of research involving both entire systems and each of its stages should be maintained.

. See also Recommendations 59, 70-95 and 106.

The Governing Council of UNEP has from its first session onwards, taken a number of decisions formulating the objectives and strategies of the UNEP energy programme[1/]. In doing this, the Governing Council took into consideration the relevant recommendations of the United Nations Conference on Human Settlements (Vancouver, 1976); the United Nations Water Conference (Mar del Plata, 1977) and the United Nations Conference on Desertification (Nairobi, 1977).

1/ Decisions 1 (I) of 22 June 1973, para. 12 (g); 8 (II) of 22 March 1974, sect. A.1.6; 29 (III) of 2 May 1975, para. 9 (f); 34 (III) of 2 May 1975; 47 (IV) of 14 April 1976; 60 (IV) of 13 April 1976; 82 (V) of 25 May 1977; 7/3 of 3 May 1979, para. 4; 7/9 of 3 May 1979.

United Nations Conference on Human Settlements
Vancouver, 1976

Recommendation C.5

(a) Human settlements are consuming more and more energy just when mankind has become aware of the need to cease environmentally degrading and wasteful use of non-renewable energy resources.

(b) THE EFFICIENT UTILIZATION OF ENERGY AND ITS VARIOUS MIXES, SHOULD BE GIVEN SPECIAL CONSIDERATION IN THE CHOICE OF DESIGNS AND TECHNOLOGIES FOR HUMAN SETTLEMENTS, ESPECIALLY THE RELATIVE LOCATION OF WORK PLACES AND DWELLINGS.

(c) This may be achieved by :

Identifying and developing new sources of energy and promoting more efficient use of energy resources, for example through innovative approaches in design and management and through financial and other incentives for energy conservation and through disincentives for wasteful consumption;

Emphasizing where possible the use of renewable over non-renewable energy sources and the rationalization of technologies which are currently known to be hazardous to the environment;

Developing and implementing special small-scale power generating, delivery and use systems more appropriate for water supply, rural electrification, and district heating and cooling, including the utilization of solar and geothermal energy and heat pumps as appropriate.

United Nations Water Conference
Mar del Plata, 1977

Hydroelectric power generation

IN THE FORMULATION OF PLANS FOR THE DEVELOPMENT OF THE ELECTRICITY SECTOR, IT IS NECESSARY TO GIVE ATTENTION IN ALL CASES TO THE ADVANTAGES OFFERED BY MULTIPURPOSE HYDRO-ELECTRIC PROJECTS, INCLUDING PUMPED STORAGE, THAT ENSURE THE CONTINUED ENJOYMENT OF THIS RENEWABLE RESOURCE WITHOUT SERIOUS DAMAGE TO HEALTH AND THE ENVIRONMENT.

United Nations Conference on Desertification
Nairobi, August, 1977

Recommendation 19

It is recommended that the conventional use of energy sources based on the use of vegetation be controlled and improved, that existing local or imported technologies for gas and electricity production, as well as for heating or cooling or mechanical purposes, be implemented as far as practicable, and that research be vigorously pursued into the use in the dry lands of alternative or unconventional energy sources that will yield simple, inexpensive, useful and socially acceptable devices to serve the needs of their people.

This recommendation implies national action to:

(a) Promote the controlled use of plant materials for fuel as part of conservational management, including the planting of woodlots, the establishment of forest reserves, the rotational collection of fuel and the introduction of improved woody

species, encourage the use of various trees which grow rapidly and whose wood could be harvested easily, and develop and implement more efficient charcoal manufacture and energy conversion devices based on plants as fuel;

(b) Establish facilities for the local manufacture of simple and efficient devices shown by investigations to be useful alternative energy sources in the dry lands. The following devices could be recommended for quick national adaptive investigations and for experimentation in pilot projects, bearing in mind the need for improved transfer and co-ordination of information to minimize unnecessary and costly duplication of effort as well as to facilitate the international sharing of presently available technology:

(i) Solar energy: photovoltaic or thermodynamic generators and water pumps based on them, water pumps combined with reverse osmosis desalters based on solar energy generators, water heaters, water distillers and desalters, cookers, coolers, food dryers, refrigerators;

(ii) Wind energy: windmill waterpumps, energy generators, and water pumps combined with reverse osmosis desalters;

(iii) Biological energy: bio-gas generators using animal waste, pyrolytic reactors designed to produce charcoal, gas and oil from agricultural wastes such as grain husks, peanut hulls, stalks of crop residue, palm leaves, etc.;

(iv) Geothermal energy: although this energy source is not yet operational, and concerns at present only certain volcanic regions of the world, it deserves to be investigated more thoroughly because of its future potential, as part of the fight against desertification, notably in the case of developing countries situated in arid and semi-arid zones;

(c) Establish distribution facilities to ensure that such devices reach the people who can use them at a subsidized price when necessary and accompanied by instructions for use;

(d) Establish appropriate maintenance facilities, including the provision of necessary spare parts for the devices, to ensure their continuing exploitation;

(e) Ensure that women, who in countries affected by desertification are largely responsible for the collection and consumption of wood for fuel in their families, are consulted on the acceptability of any new devices introduced, trained in their management and encouraged to find alternative, productive uses for any time freed by their introduction.

Objectives and Strategies of UNEP Energy Programme

Objectives:

- *To promote the understanding of the environmental effects of energy production and use, and in particular of the relationship between the levels of different emissions and their effect on weather, human health, plant and animal life and amenity values;*

- *To promote effective development of alternative environmentally sound sources of energy;*

Strategies:

- *To review in depth, and periodically update the reports on the environmental impacts of production, transportation, processing and use of all sources of energy;*
- *To identify emerging environmental priorities for research and development;*
- *To support research and development programmes, especially in developing countries, dealing with environmental problems of production and use of energy;*
- *To carry out studies on the relationship between energy conservation and environment and assist in the formulation of guidelines for energy conservation and rational use of energy sources;*
- *To increase, through experiments, training programmes, seminars and workshops, the awareness of policy-makers and the public, especially in developing countries, of the feasibility of exploiting renewable sources of energy;*
- *To support research and development programmes to harness renewable sources of energy, particularly in developing countries;*
- *To promote the exchange of information on the environmental aspects of energy production and use.*

With regard to the first objective, UNEP has been keeping under review the environmental impacts of production and use of different sources of energy, and has published a series of comprehensive studies on fossil fuels, nuclear energy and renewable sources of energy. UNEP is now in the process of developing a comparative assessment of the impacts of the various sources of energy which is expected to assist planners in making decisions on the most appropriate mixes of energy sources, including renewable sources, they should recommend for use in their respective countries.

In addition to these studies, UNEP supported an African Solar Workshop convened at Atlanta, Georgia, in 1979, and an East African Workshop on Energy and Environment convened at Nairobi, Kenya in the same year. Both provided useful fora for exchange of information about the possibilities and constraints of harnessing renewable sources of energy in the developing countries. UNEP, WHO and IAEA have recently organized an International Symposium on the Health Aspects of Different Sources of Energy at Nashville, Tennessee (June 1981); special attention is being paid by UNEP to the health aspects of new and renewable sources of energy. Furthermore, UNEP, FAO and ESCAP have organized a regional meeting at Bangkok (May 1981) to study the different problems pertaining to the exploitation and use of fuelwood and charcoal.

Since its third session in 1975, the Governing Council has been requesting the Executive Director to accord high priority to the establishment, in some of the typical rural areas of the developing countries, of a few experimental demonstration centres to harness individual or combined locally available renewable sources of energy, and to promote activities related to the development of such sources of energy. In response to these requests, experiments are under way in Sri Lanka, the Philippines and Senegal. The experiment in Sri Lanka involves harnessing solar energy, wind energy and bio-gas in an integrated way to produce electricity to meet the basic needs of the village of Pattiyapola. The solar system consists of photo-voltaic panels which transform the solar radiation into electricity to be stored in a battery bank. The windmills established at the site transform the wind energy into electricity which is stored as well. The bio-gas plant uses the animal waste from the village to produce methane which is used to run a generator for the production of electricity. The Sri Lanka experiment is the first of its kind that combines the electricity produced from different sources into a battery bank for storage. The Senegal experiment will also use wind and solar power and, in addition, will use peanut shells as fuel to provide energy to a small village. In the Philippines, individual renewable sources of energy (wind, bio-gas and small-scale hydro) are used in separate remote islands to provide the basic energy needs for small communities. Furthermore, studies on the feasibility of harnessing different renewable sources of energy are being carried out in Indonesia, Somalia and the Arab region. Special attention is being paid to the development of environmentally sound technologies and the acceptability of such technologies.

Training and research are also important components of UNEP's efforts to promote the development of environmentally sound alternative sources of energy. The different panel meetings, workshops, etc.

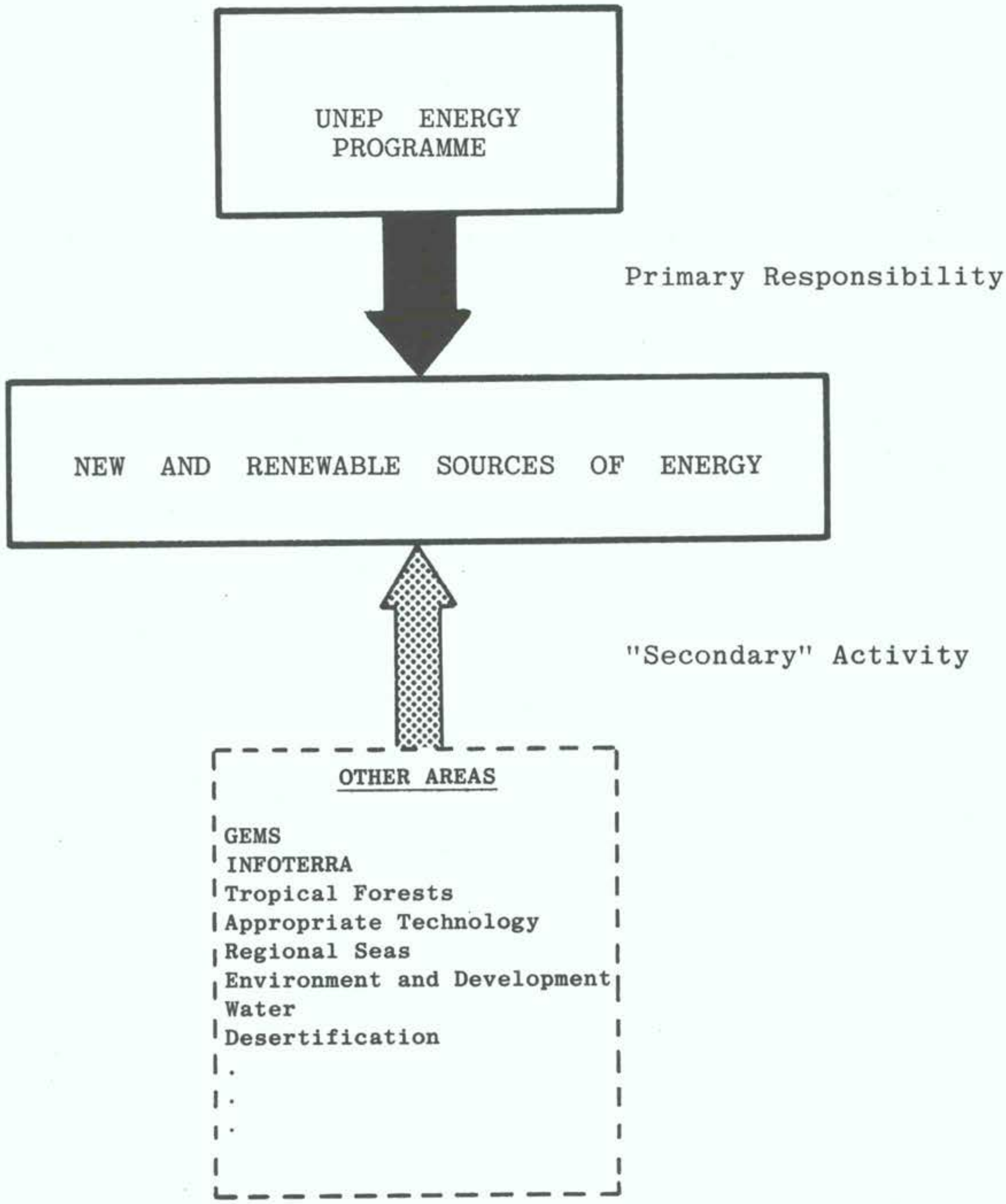
convened by UNEP provide forums for the exchange of scientific information and national experience, and have been important in promoting better understanding of the problems pertaining to the development of different renewable sources of energy. UNEP also organized a study tour on small hydro-power schemes in China in 1976 and a training seminar on bio-gas in 1980 in the same country, and has published technical reports on both. Research on the beneficial use of water hyacinth (partly for production of bio-gas) is being carried out by a number of scientific institutions in several developing countries, with UNEP's support.

UNEP is co-sponsoring an International Conference on Small Energy Resources organized by UNITAR, at Los Angeles in September 1981, and is organizing an International Workshop on Energy for Rural Development, to be held at Bangkok in October 1981. Both meetings will take account of the outcome of the Conference on New and Renewable Sources of Energy and will provide opportunities for the exchange of views to evaluate priorities for action, research and development in the areas of new and renewable sources of energy.

Several other areas of the Environment Programme are also undertaking activities (although of "secondary" or "subsidiary" nature) related to New and Renewable Sources of Energy. These areas include : The Global Environmental Monitoring System (GEMS), INFOTERRA, Tropical Forests, Appropriate and Environmentally-sound Technology, Regional Seas and Environment and Development.

Within the framework of GEMS, UNEP in co-operation with FAO and other organizations has embarked on a monitoring programme to determine the forest cover, especially in tropical regions. A pilot project in Benin, Togo and Cameroon has been terminated; a project is going on in South-East Asia and other regional projects are being initiated. Such world-wide and regional assessment of the tropical forest cover are carried out using aerial photographs, satellite imagery and information collected from governments and various sources.

INFOTERRA is a world-wide network which assists organizations and individuals in locating sources of technical, scientific and decision-oriented information on the environment. It operates as a decentralized network incorporating existing national and international information services and systems. Among the areas covered by INFOTERRA are: Energy resources and Renewable and Non-renewable resources.



Relationship Between Areas of UNEP Activity and "New and Renewable Sources of Energy"

Within the area of Tropical Forests and Woodlands, special emphasis is being given to the ecologically-sound management and protection of tropical forests and woodlands to ensure sustainable yields to meet the growing demand for wood. In co-operation with other organizations, UNEP aims at the elaboration and promotion of concepts of ecological management in tropical forest areas; establishment and strengthening of integrated pilot projects for research, training and demonstration in tropical forest areas, including development of an inter-regional project on scientific basis for rational management of tropical forests; continued development of guidelines and management tools for indigenous tropical forest and woodland ecosystems and communities which would result in regular and sustained production; promotion and assistance in the implementation of legal regimes for sound tropical forest management and protection; and the acceleration of management research in multiple forest practices, including agro-forestry, community and energy forestry. Dissemination of information, training and education are also important components of such activities.

The choice of alternative energy sources may lead in the next decade or two to utilization of the sea as a source of energy. Tidal power is already being harnessed in significant quantities in at least two coastal areas of the world. Preliminary feasibility studies have demonstrated that energy can also be generated by wave action, coastal winds, salinity gradients and vertical temperature gradients. The utilization of marine biomass (large algae) for methane production is another potential source of energy in the sea. However,thorough environmental impact studies will be required before any of the potential energy resources of the sea can be considered as safe from the standpoint of protection of the marine environment and of coastal ecosystems. This is one of the areas of concern to UNEP's Regional Seas Programme.

III. RECOMMENDATIONS

The following recommendations for action derive from the different decisions of the Governing Council of UNEP, from the recommendations of the UNEP International Panels of Experts convened in 1979, 1980 and from Workshops and Symposia sponsored by UNEP (e.g. The Africa Solar Energy Workshop convened in 1979; the East African Workshop on Energy and Environment convened in 1979; the ESCAP/FAO/UNEP Expert Group Meeting on Fuelwood convened in 1981; the WHO/UNEP/IAEA International Symposium on Health Aspects of Different Sources of Energy convened in 1981). The Recommendations of the UN Conference on Human Settlements (1976), the UN Water Conference (1977), the UN Conference on Desertification (1977) and the UN Conference on Science and Technology (1979) have also been taken into consideration.

1. Detailed systematic assessment of the environmental impacts (positive and negative) of the exploitation and use of New and Renewable Sources of Energy is a pre-requisite for the successful and sustainable development of these sources. In particular, the relationship between the levels of different emissions and their effect on climate, human health, plant and animal life and amenity values should be studied in detail. Environmental cost/benefit analyses should be undertaken accordingly to determine the most environmentally-sound technology option. In this respect, it should be noted that good management of the environment should be based upon avoiding wastage of resources and pollution. This is more appropriate and certainly more efficient than redressing environmental degradation after it occurs.

2. The development of renewable sources of energy is of primary importance for the development of rural areas and coastal zones, especially those remote from the mainstreams of development. In this context, the exploitation of renewable sources of energy should be undertaken as a part of the overall development strategies for such areas and should be directed at meeting the basic energy requirements of the rural population, agricultural development, rural industries, etc. In other words, special emphasis should be given to the development of integrated systems, for example the development of micro-hydro schemes in relation to agricultural development and provision of electricity;

the development of biogas schemes in connection with disposal of organic wastes and fertilizer production..etc.

3. Fuelwood constitutes the main source of energy in rural areas of the developing countries. Although some measures are being taken to develop fuelwood resources, and to use them more efficiently, fuelwood shortages are going to become more severe and will inevitably spread to areas where the problem hardly existed before. Massive deforestation in the developing countries is undercutting the long-term potential for increased fuelwood production. Special efforts should, therefore, be made to monitor the forest cover especially in tropical regions to provide an adequate data base of the areas covered and the rate of deforestation and to institute adequate forest management practices to protect the resource base from over-exploitation and destruction. Reforestation programmes should be undertaken at a much faster rate than, hitherto, has been the case; to ensure the success of such programmes, public education and participation is a primary pre-requisite that has to be taken into consideration. Furthermore, ways and means of increasing the efficiency of fuelwood utilization (direct combustion or conversion into charcoal and/or other products) should be developed and put into wide-scale application. Detailed assessment of the environmental and socio-economic impacts of fuelwood production and use should be undertaken to ensure an environmentally-sound management of the resource base and a more efficient use of fuelwood. To ease the pressure on the forest resource base, and to conserve wood resources, special attention should be given to the development of appropriate technologies to harness alternative locally-available sources of energy, especially those that are renewable. In other words, special emphasis should be given to the possibilities of partial "substitution" of fuelwood by other adequate sources of energy.

4. Research and development should be accelerated to introduce and adapt technologies for the exploitation of renewable sources of energy to local conditions (socio-economic and environmental); technologies should not be thrust upon recepient countries since this might detract from the success of development and use of renewable sources of energy. In this respect, pilot and demonstration experiments are of primary importance to assess the acceptability of renewable sources of energy technologies.

5. The development of new concepts for providing for renewable sources of energy, e.g. energy plantations (or Energy Farms) should be carefully assessed. Land areas required, fertilizer and water requirements, pesticide requirements, pressures on soil productivity, energy balance, fuel versus food production, etc. should be evaluated before embarking on long-term plans for the implementation of such concepts.

Within this framework which is delineated in general terms by its Governing Council, the United Nations Environment Programme could be expected to carry specific assignments that may emerge from the UN Conference on New and Renewable Sources of Energy.

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