INTERNATIONAL CENTRE FOR
ADVANCED TECHNICAL
AND VOCATIONAL TRAINING

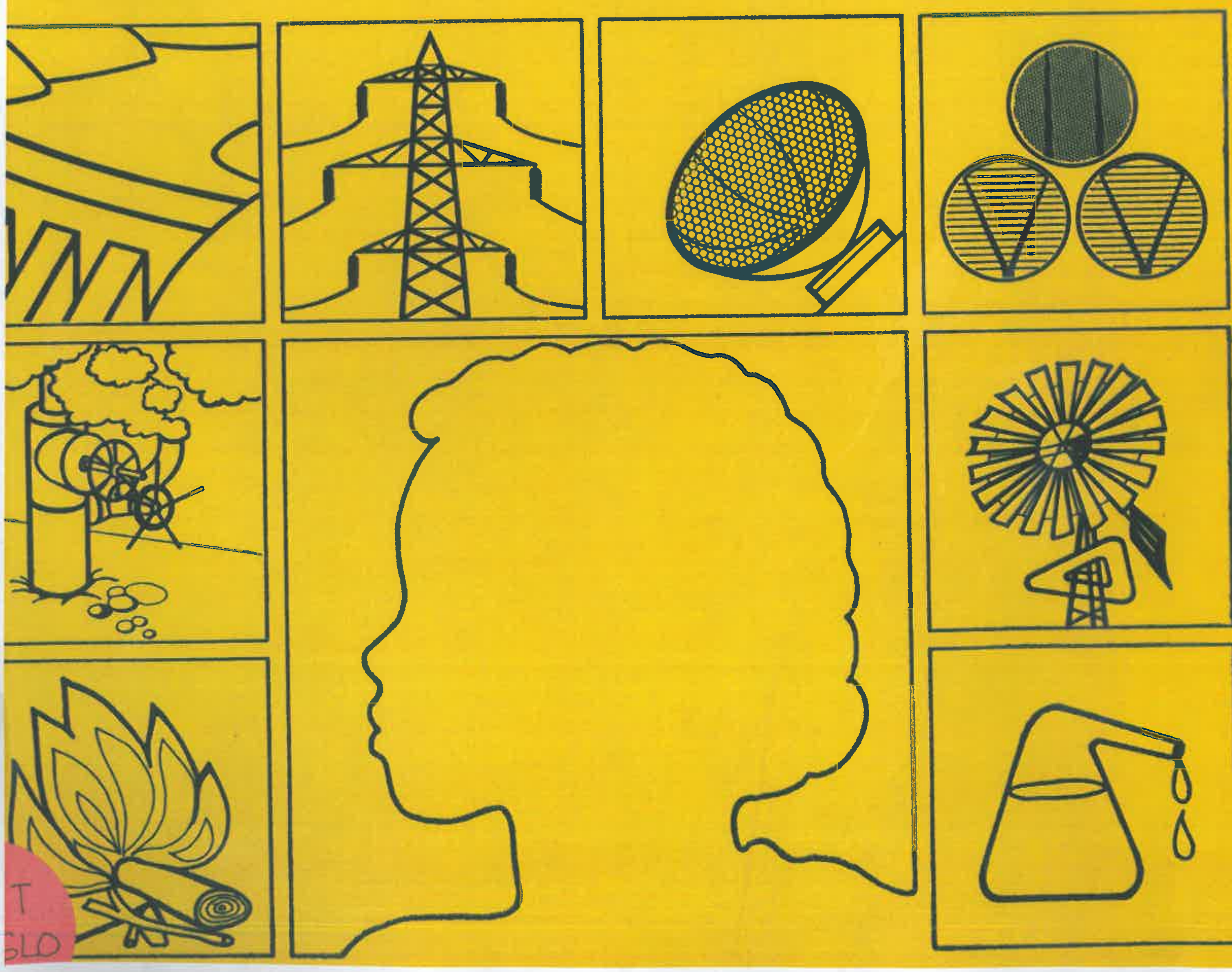
TURIN

UNITED NATIONS
INTERNATIONAL RESEARCH
AND TRAINING INSTITUTE FOR
THE ADVANCEMENT OF WOMEN
INSTRAW

VOMEN
lew and Renewable
ources of Energy

MODULAR
TRAINING
PACKAGE
1988

Pilot Test Edition



MODULE EWIII

NRSE PROJECTS AND PROGRAMMES: DESIGN AND IMPLEMENTATION

This module is conceived as a package containing all the information, examples, exercises, audiovisual and control aids necessary for:

- the **trainer** to deliver a lesson or conduct training activities;

and/or

- the **trainee** to analyse, reinforce and apply the theoretical concepts learned during training sessions;

and/or

- the **professional** as self-learning reference material to upgrade knowledge and skills related to effective integration of women in NRSE projects and programmes.

In order to reduce the learning time and improve the learning efficiency, keeping high the motivation of the user, the text of the module contains only that information and activities considered essential for the achievement of the training objectives as specified in the following pages. Additional reading material is included for those users who wish to study in greater depth specific subjects related to the subject considered in this module.

From a pedagogical point of view, the structure of the modular package consists of five components - as specified on the following page - which are easily adaptable to the needs of both the trainer and the trainee.

1. INPUT DOCUMENTS

   1.1 Target groups

   1.2 Objectives

2. BODY OF THE MODULE

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   2.2 Text

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3. OUTPUT DOCUMENTS

   3.1 Checklists on key issues for group work

   3.2 Evaluation questionnaire

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5. VISUAL AIDS

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   5.2 Transparencies

   5.3 Sound/slide package "An Overview on NRSE Applications"

The trainer will make use of the five components indicated above, while the trainee will only be provided with the material related to components 1, 2 and 3.

1. DEVELOPMENT PLANNERS, SENIOR OFFICIALS FROM MINISTRIES OF ENERGY, AND OTHER GOVERNMENTAL AND NON-GOVERNMENTAL ORGANISATIONS INVOLVED IN THE DEVELOPMENT AND MANAGEMENT OF ENERGY PROGRAMMES AND PROJECTS ON THE USE OF NRSE.

2. SENIOR OFFICIALS OF WOMEN"S ORGANISATIONS AND INSTITUTIONS AT NATIONAL, REGIONAL AND INTERNATIONAL LEVELS.

GENERAL OBJECTIVE

THE USERS WILL BE ABLE TO IDENTIFY THE ROLE OF WOMEN IN THE IMPLEMENTATION STAGE OF NRSE PROJECTS.

SPECIFIC OBJECTIVES

ON COMPLETION OF THIS UNIT, THE USERS WILL BE ABLE TO:

1. IDENTIFY THE EXISTING NRSE SOURCES AND THEIR POTENTIAL AND USE;

2. IDENTIFY THE TECHNICAL CONTRIBUTION OF WOMEN TO THE IMPLEMENTATION OF NRSE PROJECTS AND PROGRAMMES, WITH PARTICULAR REFERENCE TO THEIR ROLE IN THE CHOICE OF TECHNOLOGY;

3. IDENTIFY THE MAIN ELEMENTS RELATED TO THE ROLE OF WOMEN IN CONSTRUCTION, OPERATION AND MAINTENANCE IN NRSE PROJECTS.

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1. INTRODUCTION

Renewable energy resources occur in nature, in the **form of energy flow of indefinite duration**, as opposed to mineral deposits of finite amount. Thus, solar and wind energy, hydroelectric power and fuels of vegetable origin are considered as renewable, while mineral fuels are not.

NRSE technologies represent a significant opportunity to increase diversification and flexibility within the energy supply system. They include a large number of potentially viable options which contain feasible combinations of the various natural resources, conversion processes and energy products. Several of these technologies make important contributions to national, regional and local requirements for energy; others need still additional resources and development.

The recent growth of **interest in the exploration of renewable energy sources** in developing countries has been prompted by **two main factors:** the **instability of price of oil and gas**, and the **alarmingly rapid depletion of fuelwood supplies** in these countries.

Socio-economic development, which is associated with a growing demand for energy, has emphasised the need to develop domestic energy alternatives (and consequently NRSE).

As in many developed countries, conservation and increased efficiency in energy use are regarded as helpful but not sufficient to meet growing needs.

Renewable energy can substitute for oil in a variety of modern sector uses in transport, industry and the production of electric power. Quantifying the potential savings in oil, resulting from use of biomass, solar and other renewable energy sources is, however, difficult. The few studies which have attempted to do so suggest the possibility that renewable energy may be able to substitute **for some 5 to 15 per cent** of the oil consumed by the developing countries by the end of the century. Because of the differences in coverage, methodology and critical assumptions (for example, about world oil prices) these results can at best be regarded as indicative. However, they do point to the broad conclusion that renewable energy, while no panacea, can be expected to substitute for a small but significant share of oil consumption in the developing countries over the long run. An earlier and more substantial impact may be possible in regions and countries that are particularly well endowed with biomass.

Interest in renewable energy has also been stimulated by growing awareness of the existence of a **"second energy crisis" brought on by the depletion of forests in many of the developing countries**. In contrast to the change in oil prices, a highly visible modern sector phenomenon, the crisis in traditional energy supplies is a quiet one, but it poses a clear danger in the lives of much of the population of the developing world. Traditional renewable energy resources such as **firewood, charcoal, crop residues and animal dung**, account for virtually all of the fuel used in many rural areas, and may account for about **20 to 25 per cent of the total energy consumption** in the developing world. Africa is the most dependent upon traditional renewable resources, Asia somewhat less, and Latin America is the least dependent upon these resources. About **75% of the population** of the developing countries **uses traditional fuels, largely within households and primarily for cooking.** Most of these people have access to firewood, but roughly **1,000 million people use agricultural** and **animal wastes** to fuel their cooking fires.

The **rural energy crisis stems from the fact that the developing countries have been consuming their wood supplies far more rapidly than they are renewing them**, with grave environmental, economic and human consequences. Fuelwood harvesting to meet the energy needs of rapidly growing populations, land clearing for agricultural purposes and increased lumbering, together, are consuming the developing countries' forests at a rate of some 1.3 per cent or 10-15 million hectares a year. Deforestation, particularly on steep hillsides, has contributed to soil erosion that has reduced upland water storage capacity and increased the siltation of reservoirs (shortening their lives), irrigation canals (raising maintenance costs) and river beds (increasing the danger of flooding). The search for fuelwood has also been an important factor in the destruction of covering vegetation in arid and semi-arid areas, thus contributing to desertification. As fuelwood supplies have dwindled, people have turned increasingly to burning dung and agricultural residues, depriving the soil of valuable nutrients and organic conditioning material. It is estimated that the current use of dung for fuel "costs" some 20 million tons of foregone food grain production annually.

2. THE NRSE POTENTIALS AND TECHNOLOGIES: A REVIEW

The development of **NRSE will have its most important impact in helping developing countries meet this second energy crisis.** This **impact** should be **measured** not only **by the quantity of energy produced,** but also by the **contribution** made to **welfare and development.** Small hydroelectric units, wood burning power plants, wind pumps and other renewable sources of mechanical and electrical power, while perhaps not adding significantly to national energy supplies, can have a major impact on development and touch the lives of large numbers of the poorest people by providing power for agriculture and rural industries.

The developing countries are in some respects at an advantage in developing renewable resources of energy, for example many of them are located in the latitudes that naturally receive the greatest amount of solar radiation. For example, India receives an average of 0.17 tons of oil equivalent (toe), or 1.2 barrels of oil equivalent (boe), per square metre per year, and the Sahelian countries 0.19 toe (1.4 boe), compared with average insolation levels of 0.15 toe (1.1 boe) in the United States and 0.09 toe (0.6 boe) in Western Europe. Where rainfall and soil conditions allow, the biomass produced by this abundance of solar energy gives many developing countries another major renewable energy resource. Unlike fossil fuel deposits, which yield energy in the relatively concentrated and portable forms suitable for large-scale industrial and urban use, solar radiation and biomass are most economically exploited on a small-scale, decentralised basis, and are thus well matched to the needs of dispersed rural populations. In addition, much of the equipment needed for many of the renewable energy technologies is suitable for domestic production in even the less industrially advanced of the developing countries.

The **relatively high cost of energy from conventional sources in many rural areas of developing countries is likely to make the development of some types of renewable energy economically attractive** there sooner than in the urban areas.

The power generated from conventional sources may be much more costly in remote inland locations where high transport charges make fuel substantially more expensive.

Of course we should not be too enthusiastic in the potential use of NRSE since some technologies are not yet mature, and others are too sophisticated, so that there is the need to analyse in detail how the NRSE as a primary form can be exploited and with what techno-socio-economic implications.

2.1 FORMS OF ENERGY

Energy in its **primary** form can be of different kinds, such as:

chemical which includes:

- . fossil fuels: coal, oil, natural gas, peat....
- . biomass: wood, agricultural residues, urban refuse...

potential which includes: waterfalls and flows

kinetic which includes: wind, waves

radiation sun

heat geothermal reservoirs, ocean thermal reservoirs

nuclear uranium

The primary form of **energy** cannot be used as such, therefore it **must** in general **be converted into a secondary** or **final form** before being used as useful energy.

Important **types of secondary energy** are, for example, electricity, mechanical power and chemical.

Fig. EWIII-1 represents a flow diagram from primary energy to useful energy.

The main types of **useful energy** are **heat** and **mechanical energy**:

Heat is mainly used in household activities such as cooking, space heating or drying, and in various industrial applications.

Mechanical energy or **power** is typically used in the productive sector such as industry, agriculture and transportation.

To understand better **how NRSE can contribute to the principal energy consuming sectors,** it helps to note that:

I. **Agriculture** production accounts on average in developing countries for less than 5% of the country's commercial energy consumption. High energy prices have least effect on subsistence agriculture, but most effect on yield-increasing technologies. The improvement of farm practices is needed to make better use of energy.

There is a possibility of using solar pumps for irrigation; there is also scope for organic agriculture using crop residues. The potential competition between food and energy crops, e.g. sugar cane used for alcohol production, algae for biogas, is likely to be an important area which must be taken into consideration and in which women can play a relevant role.

II. **Household (domestic).** Of the total energy consumption, household consumption accounts for an average of 45%, but only 10 to 20% of commercial energy consumption.

Energy is mainly used for cooking. As an example, biogas can be used for cooking and lighting, while solar pumps can help for water supply. Here there is a need to select technologies in line with users' (mainly women's) needs.

III. **Transport.** This sector accounts for 10 to 20% of total energy consumption mainly used for road transport. More than half the total petroleum consumption goes on transport in many developing countries. A reconstruction of a country transport system accompanied by the improvement of energy efficiency vehicles assisted by the introduction of alternative fuels (alcohol, biogas, etc.) can contribute to the improvement of the energy situation in this sector.

IV. **Industry.** This sector uses an average of more than 35% of commercial energy. According to experts, and with the present condition of industries in many developing countries, more than 15% of energy consumption can be saved in the next ten years.

V. **Electric power.** The use of electricity has grown along with the development process and is projected to continue at an annual rate of 8 to 9%. More efficient operations and loss reduction in generation and transmission of electricity may lessen the requirements for new capacity.

Local integrated systems, exploiting NRSE, especially designed for isolated rural areas can make a sensible contribution to the saving of commercial energy sources in this sector and to the improvement of the electricity supply to rural communities, where women are also involved as primary users.

2.2 POTENTIALS AND TECHNOLOGIES

A rough estimate indicates that NRSE can certainly **contribute by the year 2000 for much more than 20% of the total world energy consumption.** Some optimistic estimates indicate that the total contribution of NRSE may rise in the year 2000 as high as 52.7 billion MWh (megawatt hours) which will perhaps be 30% of the total world energy consumption. The table set out in Fig. EWIII-2 gives an estimate of the present and future world use of NRSE, which are analysed herafter in this chapter and in more detail in Module EWIV.

2.2.1 Solar energy

The sun is responsible, with one exception, for every kind of energy on earth and has long merited the various forms of worship accorded to it by everyone, from the ancient Egyptians to modern holiday-makers.

According to the UN General Assembly on NRSE (August 1981), **solar energy** has a restricted meaning associated with the **direct capture of either the sun's heat or its light.**

The power transmitted to the earth by the sun can be assumed to be 1,500 to 2,000 kWh/m²yr; unfortunately, only a minimum percentage can actually be exploited. This is due to the fact that solar radiation is essentially diffused and highly variable, while any storage system to compensate these characteristics are still sophisticated and expensive.

Solar energy can be directly converted into thermal, electrical or chemical energy.

Thermal conversion can be obtained using:

. flat-plate collectors to heat water or air at moderate temperatures
. focusing collectors or concentrators to heat water at high temperatures by concentrating direct radiation on a small surface.

Electrical conversion can be obtained using:

. solar photovoltaic cells which are semiconductor devices which generate electricity from direct or diffuse solar radiation.

Chemical conversion can be obtained by:

. dissociation of water into hydrogen and oxygen by means of chemical cycles (still at research stage).

Some examples of the possible uses of solar energy are summarised below:

USER	NEED	TYPE OF EQUIPMENT AND TECHNOLOGY
Rural communities	Water pumping	Thermodynamic or photovoltaic pumps
	Cooking	Solar cookers
	Lighting	Photovoltaic lighting systems
	Crop drying	Solar driers, air collectors
	Small hospitals	Photovoltaic refrigerators Solar water heaters
Large villages	Water pumping	Photovoltaic or thermodynamic pumps
	Hot water	Solar water heaters
	Electricity	Electrothermal plants Photovoltaic plants
Industries	Cooling - refrigeration	Solar concentrators, solar engines
	Process steam	Solar concentrators
	Desalination	Direct evaporation (solar stills)
	Drying	Solar driers - air collectors

2.2.2 Hydropower

Water power is at least 2,000 years old. For generation, water wheels in Europe supplied mechanical power for grinding corn, washing wool and driving the bellows in blast furnaces until the 19th Century. Water power was first used in the 1880's.

Hydropower is a major energy resource next in importance to oil and **coal**; today it supplies about 23% of the world's electricity, which corresponds approximately 6% of the total primary energy consumption. Most of the world's hydropower potential is still unused: in fact 83% of the resource has in theory yet to be harnessed.

Developing countries are using only 8% of their potential water power while Europe is already using 59% of its hydropower potential and North America 35%.

Fig. EWIII-3 gives the world hydroelectric potential and the exploitation rate.

Concerning the **technology**, there are **four basic elements** in a hydroelectric scheme:

. the dam
. the penstock or channel down which the water flows
. the turbine
. the generator.

Fig. EWIII-4 shows a hydroelectric scheme.

The technology is now **mature** and well-developed, but significant improvements in design and economy are still being made.

For the exploitation of **large-scale hydropower**, four **main problems** should be taken into consideration:

. geographical: in many cases potential hydrosites are far from populated areas;

. environmental: large hydro schemes, and particularly the reservoirs they create, can have pronounced harmful effects on the local environment;

. legal: in fact, more than 200 river basins straddle international boundaries;

. political: large hydropower developments, introduced when there is no great indigenous demand for electricity, have in developing countries sometimes become closed enclaves within a country.

From an **economical point of view**, the feasibility of hydroelectric power schemes is increased by multipurpose developments incorporating irrigation, flood control, water supply, etc.

An estimate presented at the World Energy Conference indicates that there seems little doubt that much more large-scale hydropower development will take place especially in developing countries (see Fig. EWIII-5).

On the contrary, **small-scale hydro (mini and micro hydraulic power plants) prospects for developing countries look extremely good.**

Small-scale hydro - from less than 1 KW to about 10 MW of installed capacity - has several **advantages:**

. the technology is essentially the source for larger systems but simplified;

. initial capital investment need not be prohibitive;

. an area can be developed gradually with a number of small schemes;

. lead times are short.

In small-scale hydro systems women's intervention is essential in the definition of the installed capacity or, in other terms, users' needs.

Small hydroelectric power plants will become widespread in mountainous regions, and of particular significance for rural energy needs. This raises the questions of selecting proper sites from the community's point of view, their safety, and the maintenance of the plant. Care should be taken in tropical areas to ensure that the spillways below dams do not become a breeding ground for simulium damnosum, which is the carrier of river blindness. To this, women, because of the nature of their traditional tasks, are particularly vulnerable. Similar considerations apply to still waters above the dams where there is usually an increase in the incidence of chistosomiasis (Bilarzia).

2.2.3 Power from the seas

Three main **ways** have been suggested **for exploiting the ocean energy**, which covers 72% of the world's surface:

. **tidal** energy
. **wave** energy
. **ocean thermal** energy conversion (OTEC).

a) **Tidal energy** exploits the twice-daily movement of masses of water, caused by the pull of the moon. About 100 sites exist worldwide which are suitable for large-scale projects, but there are many more where smaller schemes could operate.

The total potential generating capacity of the world's major tidal sites has been estimated at 13,000 megawatts, about 1% of the potential of hydropower.

Technology is available at high cost and with difficulties due to the need to construct large storage systems, necessary because of the intermittent operation of tidal-based electricity generation.

b) **Wave energy** could harness the up and down motion of waves on the sea's surface, which is originally caused by the wind blowing over the surface of the ocean.

The technology is not yet mature and it is complex. No large application is foreseen for developing countries.

c) **OTEC** makes use of the fact that water at the ocean's surface is warmer than water in its depths.

Theoretically, an OTEC plant works like any heat engine, but with much lower temperature differentials than those used in steam turbines or internal combustion engines.

There is a very optimistic estimate by experts, which says that there is a possibility of installing up to 10,000 MW by the year 2000, but this is still only a proposal.

The technology is not yet commercially available.

2.2.4 Geothermal energy

Radioactive elements in the earth's interior are continually decaying. The heat they release maintains the earth's core in a white-hot, molten state.

This heat seeps upwards towards the earth's surface. In most areas the heat flow is tiny. But in some zones geothermal heat is more concentrated - near volcanoes, magma flows, geysers and hot springs.

There are **two** main **ways** of **tapping geothermal energy**:

. using **steam** or **hot water** which occurs **naturally**;

. extracting the **heat** from **hot rocks**, by injecting and then recovering water.

The cheapest geothermal sources are in volcanic areas and these are mostly in developing countries.

Geothermal energy can be used for electricity generation, industrial processes, space heating, and bathing. Geothermal energy, which strictly speaking is neither new nor renewable, is technically and economically feasible in areas where hot water and steam exist near the surface and where there is a demand for heat and electricity.

Development will normally be large-scale and capital intensive.

Figs. EWIII-6 and 6a show the world's geothermal generating capacity and installed low-temperature capacity.

A basic diagram of a geothermal power plant is shown in Fig. EWIII-7.

2.2.5 Wind power

Windmills have been known since the year 2000 BC, when they were used in Babylon for irrigation.

The **power of the wind is proportional** to the **cube of wind speed**; this means that small variations in the annual average wind speed result in large variations in the available energy.

Wind power has a **great potential** for:

. **small-scale water pumping**, and
. **electricity generation** for isolated countries

but it can also be used for:

. **water desalination**: experience in India suggests using windmills for driving pumps in small reverse-osmosis desalination plants;

. **air-conditioning**: Pakistan and Iran still use small roof mounted wind catches, which draw in air through soaked matting and cool house interiors;

. **shipping**: recently, Japan has launched a sail-assisted oil tanker.

The technology is commercially available and is based on two types of wind machines: horizontal axis and vertical axis; Figs. EWIII-8 and EWIII-9 show the various types of machines.

Today there are two main uses for wind power: pumping water and electricity generation with direct back-up (i.e. with diesel generators).

It is accepted that in appropriate areas wind-generated electricity is already economic.

The wide diversity in designs appears to reflect both the need for different approaches to deal with different wind regimes, fabrication techniques, and applications and the fact that experience has not yet sorted out all the advantages and disadvantages of competing designs. Some approaches to windmill designs emphasise minimisation of cash costs, and keeping materials, fabrication and maintenance requirements within the capabilities of local artisans. The resulting "appropriate technology" designs appear to provide least-cost solutions in many cases, at least where low pumping heads permit low unit sizes and where modest windspeeds permit light-weight designs.

The cost of harnessing wind energy in a given area has been estimated at 20 US cents/kWh assuming a 5.5 hour/day operation with winds of 5 metres/second (11 mph) using locally manufactured or artisan-built windmills. If these cost estimates are correct, this type of windmill can compete with conventionally powered pumps in the same areas if connections to a central electrical grid are not available and pumping heads are low. Winds are not generally as strong in the tropics as they are at higher latitudes, but there are areas where trade winds or geographic features such as mountains and cost lines produce average windspeeds of over 5 metres/second. Among the most interesting areas for wind-powered water pumps would appear to be parts of northern Argentina, Chile, Mexico, Peru, northeast Brazil, coastal areas of Africa northward from about Senegal in the west and Somalia in the east, India, Pakistan and the People's Democratic Republic of Yemen. Windmill-powered pumping is generally more competitive for relatively shallow water sources that require relatively small pumping capacity.

Wind-driven electric generators are available commercially in unit sizes up to at least 15 kilowatts rated capacity. Some of these can produce power at costs of 25 to 50 US cents/kWh at low load factors and 5 to 15 US cents/kWh at high load factors in locations with average windspeeds in excess of 5 metres/second.

2.2.6 Biomass

Biomass includes, strictly speaking, **all living material, whether plant or animal.**

Basic to all energy in biomass is the **photosynthetic process:**

- the green chloroplasts in the plant cells can convert carbon dioxide and water into biomass and oxygen by using solar electro-magnetic energy. The **energy** now **present** in **biomass,** therefore, **is originally solar energy;**

- where biomass is burned, the stored energy is released as heat which can be used, for example, for cooking or space heating. The chemical reaction taking place is in fact the reverse of the photosynthetic process;

- it will be clear then that **all biomass has an energetic value.** However, not all types of biomass have an equal fuel value. The fuel value may be impaired by ash content, and particularly by moisture content. Ash content varies by species and by plant tissue, e.g. tree leaves generally have a higher ash content than wood. Rice husks contain a high percentage of silica. Ash content virtually cannot be changed. Moisture content, however, can be reduced by drying.

The energy present in biomass can be made useful in various ways.

The most common one is **direct combustion**: burning biomass in the presence of oxygen (air).

Wood biomass also may be converted into **charcoal**, which in turn can be burnt.

It is also possible to **gasify biomass**, whereby the gases may be burnt or, after cooling and cleaning, can be used in internal combustion engines.

Certain **plants** produce **hydrocarbons** which have gasoline or kerosene-like properties. Also certain **plant oils** can be used as diesel fuel, while the sugars or starches produced by other plants can be fermented and distilled, producing alcohols.

Anaerobic fermentation of plant material or organic wastes results in **biogas**, mainly methane.

Organic wastes and residues are still forms of biomass. Their (sometimes low) energy content can be made useful by direct combustion (e.g. cow dung) or anaerobic fermentation (biogas).

Energy from biomass can be obtained through **two processes: thermochemical** and **biochemical**.

Thermochemical process: operated on lignocellulosic materials including wood, industrial and agricultural residues. Includes:

. direct combustion
. gasification
. pyrolysis
. direct liquefaction.

Biochemical process: operated on lignocellulosic material and agricultural products and residues, or urban or industrial wastes with high content of sugars and starches:

. anaerobic digestion (biogas generation)
. alcoholic fermentation (ethanol and methanol).

It will be clear that biomass in its many forms is an important source of energy:

Fuelwood

Firewood used for cooking accounts for 10-12 billion kilowatt hours (kWh) of energy. In Africa, 60 per cent of total energy is fuelwood and in rural India it accounts for 93 per cent of total energy consumption. Gathering fuelwood is contributing to deforestation and erosion. Shortage of fuelwood is the undisputed energy crisis affecting most of the world's poorer countries. Nevertheless, with better forestry practices it is one of the most promising of the new and renewable energy sources. Among the recommendations likely to be made are fencing specific plantations for fuelwood and the wider adoption of the old European practice of coppicing. In this, a mature tree is cut back low to the ground but with enough stump to permit lateral shoots to sprout. These coppice poles may then be harvested progressively. (Fig. EWIII-10)

Ethanol

Growing sugar cane for the production of ethyl alcohol by fermentation is the best known example and Brazil is the best known practitioner.

The use of a mixture of petrol with up to 20% by volume of alcohol requires no adjustment to car engines.

Other sources of biomass suitable for ethyl alcohol production are sweet sorghum, beet, cassava, corn, babassu palm nuts and potatoes. When the starting material is starch (as with the last four) another process has to be introduced to make starch into sugar first.

Methanol

One virtue of methanol is that most of the source material is waste that cannot be used as food. The sources are wood, crop residues, grass and waste fibres. The feedstock is cooked to give carbon monoxide which is then combined in the presence of a catalyst to make methanol. Among the problems, there is the fact that methanol cannot be mixed with petrol and that only large-scale plants are economical, which is not the case with ethyl alcohol (ethanol) production from biomass.

Methane

Almost anything of biological origin can be used to make methane.

Animal and human wastes and wet crop wastes, or even specially grown aquatic plants, algae and water hyacinth, are ideal sources. The key condition is that bacterial action should take place in an atmosphere where there is no oxygen - in anaerobic conditions; the key device is a digester which can be kept warm and sealed from the air usually by a water seal. Animal manure and other wastes are mixed with water to form a slurry and pumped into a digester where they are retained for two weeks or so.

The gas produced by the bacteria feeding on the organic material consists of two parts of methane to one part of carbon dioxide which ideally is stored in a separate gas holder. (Fig. EWIII-11)

China and India are world leaders. Seven million Chinese digesters are in operation. They come in all sizes, from family to large village size. In China, gas is used for lighting and cooking but can equally well be used for stationary engines and electricity generating and transport. The resulting sludge is used as organic fertiliser and soil conditioner. Even in rich countries methane production may increase because it is the answer to the environmentalists' prayer.

Pyrolysis gas

Hydrocarbons, ketones and aldehydes, which burn like fuel oil, can be made by heating dry domestic and municipal waste under pressure at 500°C in the absence of air. The technology is still under development, but plants dealing with 200 tonnes of refuse per day are in operation in the United States and Europe. (Fig. EWIII-12)

Charcoal

Many pyrolysis processes leave as a by-product char - close to another pure form of carbon which, when made by traditional means, is called charcoal. The material is produced by the slow burning of wood with a very restricted air supply. Compared to wood, it provides much greater useful heat, stores better and produces less pollution. Ten per cent of total fuelwood is transformed into charcoal for easy transport into towns and cities. More efficient methods of converting wood to charcoal would result in a higher yield. (Fig. EWIII-13)

Oil-producing plants

These are headed by the oil palm (Elaeis guineensis) in respect of oil production (4-5 tons per hectare per year). Some other crops are soy beans, peanuts, castor beans and coconut palms. Palm oil can quite easily be converted into a fuel for diesel engines. Oil palms would produce annually some 20 tonnes/ha in fruit or 4 tonnes oil/ha, finally producing 4 tonnes of fuel, i.e. some 5,000 l/ha.yr. The process of fuel production is much simpler and energy-efficient than in the fermentation process.

Biomass

This constitutes an extremely important source of energy. In fact according to approximate estimates it can contribute for 15% of the world's energy needs corresponding to 20 million barrels of oil a day (the present energy need of the United States!).

For one quarter of the world's population, mainly living in developing countries, **biomass** (mainly in the form of fuelwood) represents the **major source of energy.**

The **technologies** for the energetic exploitation of biomass are today **mostly mature**, but there are still many difficulties in diffusing them in developing countries because many of them have only recently been developed in industrialised countries and still need to go through a realistic transfer and adaptation process.

2.2.7 Peat

Peat is on the borderline between fossil fuel and living biomass and accounts for 1.1 per cent of world fossil fuel reserves. It is estimated that 210 million tonnes a year are being added to world peat bogs. The Soviet Union burns most of its 70 million annual tonnes in power plants which generate 3,500 megawatts. Peat gasification is less expensive than coal gasification and produces four times as much gas.

2.2.8 Oil shale

Oil shale is a rather vague term applied to sedimentary rocks containing kerogen, a complex mixture of polymers which when heated produces oil. Oil shale's attraction for innovators lies in the fact that the reserves of oil it represents are several times larger than conventional oil reserves. The earliest exploitation techniques depended on mining the rock and heating it separately. The problem is that the resultant rock is more voluminous than the original, so huge disposal problems are caused. Interest centres now on in situ extraction of oil. In principle, air is pumped down a bore hole, some shale is burnt and the heat is enough to mobilise the rest of the oil. This extraction process is grossly inefficient and may not be economic at current prices.

2.2.9 Tar sands

Tar sands are oil-bearing sands in which the oil is so viscous that it does not flow. Like oil shales, tar sands represent petroleum reserves several times greater than those in conventional oil reservoirs. Extraction methods shade into those used with conventional oil-steam, or hot gas injection. Even so, the fraction of oil extracted is very low - five to ten per cent. The largest commercial operations depend on mining the rock and washing it with hot water. So investment costs are very high.

2.2.10 Conclusions

While **many developing countries have favourable conditions** to **develop and NRSE**, the **pace** at which the full potential of this resource can be developed will be **determined by the ability** of the countries to:

- **develop** adequate data on sources and uses of renewable energy;

- **enhance** their technical capabilities;

- **design** systems that can deliver renewable technologies in socially and culturally acceptable forms to large numbers of energy users; and

- **strengthen** institutions for energy planning and programming.

Most developing countries lack the data for a realistic assessment of the present and future role of NRSE in their economies. Hard information on existing resources, uses, and costs of NRSE is available from only a limited number of case studies, and there have been few efforts to take careful stock of the availability and distribution of national resources for the production of energy from biomass, solar radiation, the wind or small hydro sites. In most countries, systematic efforts to fill the most serious data gaps are a prerequisite for moving beyond pilot projects and isolated investments to the stage of rational selection of development priorities and sound programme planning.

In Figs. EWIII-14 and EWIII-15, there are two tables which show comparative figures between heat and electricity produced from NRSE or from commercial fuel.

3. WOMEN'S ROLE IN THE CHOICE AND ADAPTATION OF TECHNOLOGIES

3.1 INTRODUCTION

Many cases of **rejection of NRSE based installations** and also of the responsibilities attached to their introduction **have been recorded.** Such reactions cannot be attributed merely to lack of interest, cultural barriers or inherent conservation of poor rural people. On the contrary, their decisions are often based on a rational comparison of cost and benefits of the existing and the new options. Cases of incomplete adoption or rejection of facilities become understandable when viewed in the light of decision-making, work and position of women. Facilities, regardless of the excellence of construction and function, will not achieve their objectives if they are not used. Achievement of programme objectives will be affected by users of the facilities. **Women** as one of the primary users of energy sources, and as frequently the first to use NRSE based installations, **may** thus **be singled out for the intensive user education so necessary for a project's success.**

3.2 ASSESSMENT AND CHOICE OF TECHNOLOGIES FOR NRSE PROJECTS

Technologies for NRSE projects have often **failed because** they are **inappropriate, too complicated** or **difficult to operate and/or maintain.** Simple rudimentary methods should be used and developed using local materials in view of lower costs, and the possibility to provide for greater self-reliance from the community to the national level. The technology should be adapted to small-scale applications, suitable for community participation and management.

Judging the suitability of a technology presupposes knowledge about the function(s) it has to perform. With NRSE technologies, the functions closely relate to a particular socio-economic and natural environment. For a proper assessment, the **technology and its environment** should be **considered as a system** with its input and output characteristics in an institutional and organisational framework. The input and output characteristics refer to socio-economic and environmental aspects. These will be specified in the following paragraphs.

Assessment of an NRSE technology is then done against the **characteristics of the energy technology system**: which are **technological, economical, social, institutional and environmental.**

Technological characteristics

e.g. technical feasibility of design and construction, realiability, lifetime, form and scale of the output, effectivity, efficiency, requirements for operation, maintenance and repair, versatility, sophistication, input requirements (e.g. type and form of fuel, lubrication, etc.), convenience, etc.

Economic characteristics

e.g. capital costs for device, auxiliaries, support structures, installation and commissioning, variable costs for fuel, operation, maintenance and repair. This leads to unit costs, e.g. per unit of time, unit capacity or unit energy, etc.

Institutional characteristics

e.g. organisational structure required to manage the technology, proper type of ownership, requirements to production of the technology and structures for support (services, fuels, etc.), required skill level, proper dissemination and financing structures.

Social characteristics

e.g. acceptability, type of beneficiaries and distributional aspects, interference with social structures, potential employment generation, spin-offs, adverse impacts, requirements to accessibility of capital and currency, etc.

Environmental characteristics

e.g. consequences of using and not using the technology (e.g. ecology, pollution), ditto of production and installation, environmental risks, etc.

Where the technological characteristics could be judged by considering the technical device as such, this is less and less the case for the subsequent characteristics. For instance, the social and environmental characteristics link the technology to its environment, and a proper assessment would require a full appreciation of the technology system.

Neglect of institutional characteristics has led to total failures of NRSE projects, whereas neglect of social or environmental characteristics sometimes has led to adverse effects of introducing the technology.

Assessment of technologies essentially implies judging the technologies against all the system characteristics.

The analysis of the above characteristics of the energy technology system confirms that the role and contribution of women is essential for their identification and definition, since women are a fundamental and active human component of the system.

The **technology** used in NRSE projects **must be acceptable, affordable and it must work!**

An inexpensive, attractive, well-placed water pump is pointless if it keeps breaking down and the community cannot afford to pay for repairs (e.g. imported spare parts). Likewise, an improved cooking stove which technically works perfectly but doesn't fit within the traditional environment and which requires the use of types of pots which are not available in a specific rural community, is useless.

Failure to involve women in the initial testing of new technologies, such as water pumps, stoves, biogas digesters, etc. can result in reduced effectiveness and use.

There is no overstressing the importance of selecting NRSE technologies appropriate to the social and economic conditions of the project communities. "Appropriate technology does not necessarily mean simple technology", but a technology specifically designed for the conditions on which it must function. Among the **technological characteristics**, some are extremely important:

1. system design
2. levels of service
3. costs
4. maintenance needs.

The success of any community energy project depends upon the users' choice and their perception of the quality of the energy source, the difficulty in production (i.e. biogas production), and social interaction during the exploitation process.

These are factors which are of significant concern to women and which further throw light upon the important role women have to play the energy sector interventions. The climatic and site conditions, population, socio-cultural factors, and the institutional framework are important to guide the selection and design of the most appropriate technology. The basic precept, therefore, is that the choice of technology must be appropriate to the existing socio-economic, environmental and institutional setting. These factors would also further determine the selection of the appropriate levels of technology.

The **main** factors that **discourage women's participation** are:

1. socio-economic, cultural and political factors are not considered;

2. lack of consultation in project formulation;

3. lack of organisation to sustain women's participation;

4. the fact that men often take over a project when the women's input has been identified as successful;

5. powerlessness of women, particularly those who are among the landless.

<u>How to pay attention to women</u>

There are **two** major **ways** for NRSE projects to consider women's participation in the choice of technology:

a) by including information on women in the project area in the data to be collected, and using it in planning; and

b) by assisting women to play an active role in the project, particularly in decision-making about the technology and design aspects and in accompanying training activities.

Such attention to women during project planning is even more vital where there are large numbers of female-headed households in the project area, either on a temporary or permanent basis. In such instances, women will take over many of men's roles; if this is not recognised during planning, it will lead to unworkable assumptions.

3.3 WOMEN'S ROLE IN CHOICE OF TECHNOLOGY FOR NRSE PROJECTS

When new facilities are not used at all, the argument is put forward that women should be "educated". Women make reasonable choices and have some basic, although not necessarily complete, knowledge about different energy facilities. Therefore, as women are the primary users of facilities, it is necessary to broaden knowledge and take into account their preferences when installing new facilities.

It is essential to find out about local needs through **participatory research** and **continuing consultation** at the community level, especially with women. In the design and application of community accepted technologies, **women's** needs and their **physical state** such as pregnancy and physical capability should be taken into account. Women's views and opinions are critical in this regard, especially regarding the choice of technology, and developing new and appropriate technologies to be introduced. They could **satisfy long and short-term needs** as defined by women. This will serve to influence acceptance and use of NRSE based systems. It will be largely up to them whether facilities will be used and maintained.

Women often place a different value than men on such positive features of facilities such as: privacy offered by the superstructure, reliability, safety, convenience, comfort, attractiveness, etc.

3.4 WOMEN'S ROLE IN THE ADAPTATION OF TECHNOLOGY

In reaching technology decisions, full advantage must be taken by the women's knowledge of the energy situation at local level.

Women as energy users can provide important information which can lead to the adaptation of the technologies to their social and cultural characteristics and to the community energy needs and operating conditions. **Women** should also be **involved** in the **decision-making** and the **design** of energy related facilities.

3.4.1 Appropriate technology issues

Self-improvements in NRSE use may also be stimulated by the **development** and **diffusion of appropriate technology**, such as cooking stoves, bio-digesters and solar water heaters. Some **bibliographies** and manuals on appropriate technology have been prepared, which include self-improvements for energy equipment. However, it is not always clear whether they reach women and women's organisations in rural and urban fringe areas. **Technology centres** located in large cities are **difficult** for rural women to attend or to obtain information and technical assistance.

Some programmes have made special efforts to reach their target groups. In Indonesia, the Ministry for Women's Affairs has published a handbook on appropriate technology for village women. In other countries, courses have been organised to train women in labour-saving technologies.

An interesting strategy to diffuse knowledge of appropriate technology for women's self-improvement has been followed in Senegal. A travelling exhibition of village technologies was organised by the Ministry of Rural Development and Water Supply to tour all rural communities. During its one-week stay in each village, a seminar was organised to introduce the various technologies to the women. A similar travelling exhibition focusing on environmental sanitation was organised in Ghana as early as 1948. After villagers had been escorted around the various exhibits, women were selected to receive intensive training at rural training centres.

"Whilst total results did not add up to the expectations of the organisers, there can be no doubt that considerable improvement was achieved in cleaning up villages and improving environmental hygiene. The travelling exhibition itself was manufactured locally and, whilst some of the exhibits might have been deemed crude, there was no doubt of the interest that they stirred in the villagers of Transvolta".

3.4.2 How to involve women in appropriate choice of technology

The technology for NRSE projects and programmes must be acceptable, affordable and it must work. If women are to begin taking hold of technology in their daily lives, they could:

- **work through** their local clubs and associations to mobilise community action in favour of the new facilities;
- **participate** on survey teams to identify community energy needs;
- **choose and test** those technologies they will later use daily;
- **monitor** operation defects in energy systems;
- **keep** a stock of spare parts;
- **do** routine maintenance and minor repairs;
- **be** a liaison between local authorities and district/regional technical services.

In considering a **technology**, one **question** that must be asked is: DOES IT WORK? The answer to the above can be found in answers to more specific questions such as:

1. What does it do for the lives of women?

2. What changes in women's work patterns will be required to use it? Does it use local initiative or allow for local development?

3. Is the engineering design appropriate to women? Is it easy to maintain? Does it really encourage self-reliance? If so, how?

4. Is this technology the most affordable option? Can women afford the cost? What are the benefits for women and community?

3.4.3 Role of women's organisations

The following policies are recommended:

. **Women's organisations** could **organise** or **support** research prior to the implementation of technology and ensure that adequate technology is chosen for the community, particularly women with existing economic, environmental and socio-cultural context. By consulting with technical agencies and women at local level, it could be ensured that:

  - engineering design is appropriate for women's use;
  - the structure of the energy equipment and devices (stoves, bio-digesters...) conforms to cultural rules;

- women can repair facilities;
- women can afford to maintain them.

. **Women's organisations** can **contribute** to decision-making about NRSE projects and demonstration programmes by providing information on:

- locations for facilities that are convenient for the community;
- schedules for using facilities that fit women's work patterns or time use;
- design of technologies that also suit women, and that are easy for women to use.

. **Women's organisations** can **encourage** the involvement of women in the national programme at all levels:

- help recruit women managers, engineers, teachers and trainers;
- prepare lists of active local women's groups which are near proposed programme sites;
- provide a roster of women candidates for training courses;
- support activities of local women's organisations contributing to improved NRSE projects and programmes, by providing funds, equipment and supplies, technical back-up and information materials;
- organise fund-raising campaigns.

4. WOMEN'S POTENTIAL CONTRIBUTION TO THE IMPLEMENTATION OF NRSE PROJECTS AND PROGRAMMES

4.1 HOW TO INVOLVE WOMEN IN TECHNICAL ASPECTS OF NRSE PROJECTS

Although planners and policy makers may rate those areas in which facilities have been constructed as being served, it is increasingly clear that many facilities do not function for long periods or have broken down completely. This not only means a loss of investment, but also hampers the attainment of energy objectives and other developmental benefits. Thus, for continued functioning, limitation of breakdown and quick repairs are essential. **Women** can contribute in several ways. As users and managers of traditional energy sources they **may have knowledge and experience useful for project designs.** For example, they know the location, reliability and quality criteria, and therefore should be consulted in surveys for energy demand and availability assessment.

Their personal interest in good and reliable facilities can also **motivate villagers** to follow closely all local **construction work**, for example by contractors, provided they are involved in the project and know which aspect to pay attention to.

Women can **often contribute to** the **construction** and **maintenance** of equipment and installations based on NRSE in a community.

Whether the work is suitable for local women depends on the actual tasks, the type of technology, and the availability of low-cost spare parts. A review of the daily and monthly operation of photovoltaic water pumps does not reveal any task that could not be done or organised by women. As users, women are most affected by poor operations. Their **greater participation in local management** may well result in better performance of operations and longer life of equipment.

The question has also been raised whether **women**, and the community as a whole, should be **more directly involved in the choice of technology** if continued functioning is to depend largely on local maintenance.

The adoption of simplified energy technologies may be a better solution than the introduction of more efficient but highly sophisticated technologies for which local maintenance and servicing cannot be guaranteed.

Improving availability of energy sources and fuels through NRSE projects and involving women in all project activities also implies recognition of their domestic and economic roles. It enhances their status, increases their skills and capacities for developmental activities in their households and communities, and can stimulate organisation for joint problem solving.

Women's associations can play a valuable role in achieving these basic needs for all by identifying women's needs and enriching national resources, and at the community level, forming focal points for local improvement. Women representatives and groups can also have an important role in agency projects on NRSE projects. Their personal experiences of difficulties in energy supply emphasises that women are particularly interested in the practical benefits of these projects.

4.2 BUILDING OF FACILITIES

Community contribution to construction consists mainly of unskilled labour for site clearing, digging and transport. Women have been involved as voluntary workers and motivators of voluntary labour, and as construction workers paid in food-for-work or cash.

In many countries, voluntary contribution or self-help is advocated to reduce construction costs for project agencies. Women can contribute considerably to these savings, both directly and indirectly. Apart from cost-savings, well-organised self-help can aid the development of technical and management skills in the community. These skills can be built on in turn to set up local maintenance and administrative systems. However, in spite of their active participation in physical work, participation of women in local management is minimal, as reported in various projects.

4.3 OPERATION AND MAINTENANCE

There is a growing evidence and increasing concern within governments and the development agencies, that poor operation and maintenance practices have in many instances largely contributed to a decreased utility, or even to an early failure of newly constructed energy facilities.

The introduction of proper operation and adequate maintenance practices would relieve this situation and help ensure that the resources available are utilised in the most effective way to confer maximum and enduring benefits.

Women, as part of primary users and beneficiaries, **can contribute** greatly to **adequate use and satisfactory functioning of NRSE projects if properly trained.**

Participation for adequate operation of new energy facilities begins in the planning phase. In some cases, traditional norms and social control on the use of energy sources and the sense of communal ownership of new NRSE facilities are strong enough to guarantee proper use and maintenance. Often, the manner of use is a form of management as it protects the durability or quality of the facility.

When women are involved in maintenance arrangements they should be consulted as a group rather than as individuals to find a joint solution.

Small, simple and locally-contained systems have even been handed over completely to a women's association. For example, the urban waste recycling plants which produce compost for locally owned vegetable gardens and to sell to generate funds are run by a women's cooperative in a low-income urban neighbourhood in Mexico. These women have also trained women in another community on the operation of these plants. The cooperative has chosen a woman head of household to be caretaker. Again, this may reflect their awareness of the socio-economic needs and greater independence and job motivation of such women.

Although the dedication and personal interest of women are advantages, they are not all that is required for good management. Energy committees and boards of user cooperatives may have many tasks, such as supervision and organisation of operation, maintenance and repair, finance, accounts and record keeping, hygiene improvement, education, and communication with the users. Therefore, **special training** for local communities is necessary.

4.3.1 The place of operation and maintenance in the project

Operation and maintenance are affected by a wide variety of factors such as matters concerning site conditions, socio-economic factors in the supply area, the inclusion of operation and maintenance considerations during project planning and development, the institution and managment structures, the use of appropriate technology, resource availability, etc. **Operation and maintenance**, including preventive maintenance, is recognised as an **integral phase of the project cycle** which is initiated by project identification and proceeds through phases concerned with its planning, design and construction, operation and maintenance and evaluation. Despite this recognition, there has been a tendency to look upon that part of the cycle which culminates in system construction as a self-contained achievement, overlooking the vital fact that uninterrupted operation and proper maintenance are essential to achieve the benefits for which the project was planned.

In drawing up of design parameters, the design of physical facilities, the selection of equipment and the choice of constructional materials and methods, due consideration should be given to women's needs before operation and maintenance implications of decisions are made. Of particular relevance is the need to:

(i) ensure that the adoption of technology for community needs, particularly women's, is understood. Equipment should be operated and maintained by community women workers with the minimum of supervision and back-up support;

(ii) select equipment which is socially acceptable and robust to meet the operational demands imposed upon it. In this connection, the selection of equipment should be based not only on initial capital cost considerations but should include also the capitalisation of operation and maintenance costs over its expected life;

(iii) install equipment for which spare parts and the tools and plant required can be locally obtained (local workshop and storage of spare parts should be foreseen);

(iv) take into consideration local customs, traditional attitudes before the choice of constructional materials and methods;

(v) incorporate adequate quality control of purchasing and installation, and adequate testing during installation and construction to detect defects before being places in operation or before being buried.

Preventive maintenance is considered to be a systematised and periodic maintenance procedure applied to the components of a system in order to minimise breakdowns, ensure their efficient working, and prolong their respective lives. Such maintenance is not to be confused with the corrective action taken to repair or replace system components after a breakdown has occurred, as the latter is not the subject of a planned procedure but rather a response to an operational requirement. Essentially, a preventive maintenance programme consists of organising and managing the activities required to carry out predetermined and periodic maintenance procedures to system components installed within a defined operational area. Such a programme will be based on:

(i) the identification of the frequency and location of the tasks to be performed and the allocation of responsibility for undertaking these tasks;

(ii) the identification of the resources required to carry out the tasks, expressed in terms of finance, manpower, tools and plant, workshops, transport, consumable stores, etc.;

(iii) a reporting system which will enable programme performance to be assessed and any necessary adjustments introduced so as to improve efficiency.

A matter of major importance concerning the transition between the development and the operation and maintenance phases of the project cycle is that in most circumstances there will be a significant change in the staff responsible for construction and those responsible for subsequent operation and maintenance. Continuity in the knowledge of system layout and equipment installed is therefore not guaranteed. To overcome this deficiency, arrangements should be made for:

(i) operation and maintenance staff employed on site during at least the final stages of construction, so as to become familiar with the system and to participate when plan and equipment are being tested and run in;

(ii) the provision by the development agency of complete "as built" record drawings. These drawings should clearly show the layout of the total system, indicate materials and components.

Information from the manufacturers of equipment which has been installed, such as descriptive material, should be carefully retained for future reference. Equally simple, clearly understood instructions in the local language, supported as required by simple illustrative drawings, should be provided as necessary by the technical agency for on-site use.

To operate an installation and implement a preventive maintenance programme there is a need for trained human resources whose qualifications and training needs, duties and location will depend on the size of the service area.

Community workers, particularly women, can perform such tasks as the tightening of bolts and the lubrication of pivot points on handpumps; the changing of standpost tap washers; the inspection of pipelines to detect leakage; the periodic opening of washout valves, etc. The importance of such work should, however, not be underestimated as it is on the basis of **regular** simple **preventive maintenance** of this type by locally employed staff that **system life** can be significantly **extended at minimum cost**, early recognition made of matters requiring corrective maintenance and proprietary community interest aroused and developed.

Small rural energy supply systems which utilise appropriate technology do not normally require highly qualified or specialised resident staff. In general, such staff will be required to perform a wide range of relatively simple tasks. In some maintenance systems, trained community workers do all operations, preventive maintenance and simple repairs. Until recently, women have seldom been trained as local caretakers. As this work can usually be done by either men or women, this can be attributed mainly to socio-cultural objections from authorities and project workers. The following reasons have been put forward for their lack of involvement: women do not want to do unpaid work (do men?); they are shy and illiterate (are all men literate?) they are often away at the market; they are tied to the house and cannot report or go about the village; they are afraid to go out at night to repair a pump (is that necessary?).

In other cases, women have been trained to do all preventive maintenance and sometimes simple repairs. Factors contributing to this choice include high male migration and mobility and linkage with a women's project or organisation.

4.3.2 Evaluation

Women must participate in the programme or project evaluation process, so as to allow necessary modifications to be introduced in the frequency of task performance, the use of better materials and tools, improved utilisation of staff and equipment, and apportionment of responsibility with the objective of minimising breakdowns and prolonging the life of the system.

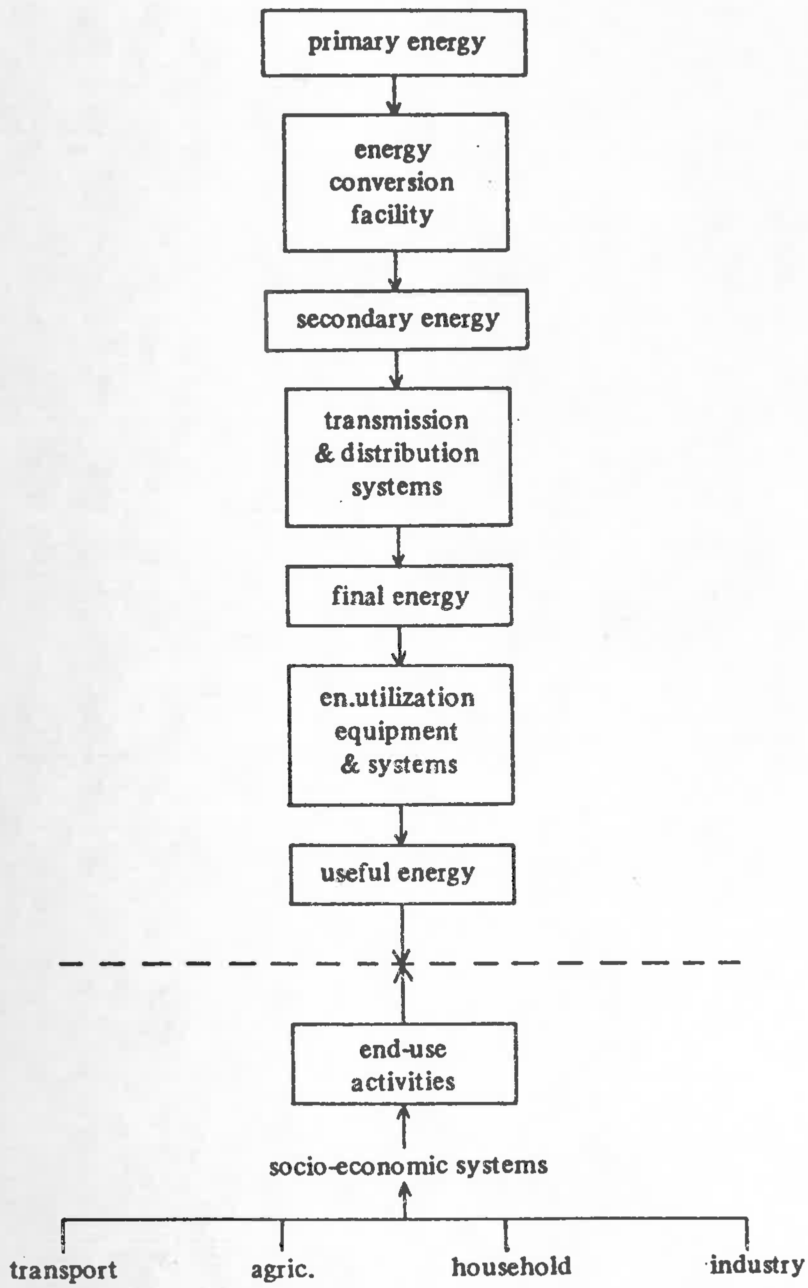

primary energy
energy conversion facility
secondary energy
transmission & distribution systems
final energy
en.utilization equipment & systems
useful energy
end-use activities
socio-economic systems
transport
agric.
household
industry

FIG. EWIII-1

PRESENT AND ESTIMATED FUTURE WORLD USE OF NEW AND RENEWABLE SOURCES OF ENERGY

Source	Present use in billion (10^9) KWh	Utilization in the year 2000 in billion (10^9) kWh
Solar	2-3	2,000-5,000
Geothermal	55	1,000-5,000
Wind	2	1,000-5,000
Tidal	0.4	30-60
Wave	0	10
Thermal gradient of the sea	0	1,000
Biomass	550-700	2,000-5,000
Fuelwood	10,000-12,000	15,000-20,000
Charcoal	1,000	2,000-5,000
Peat	20	1,000
Draught animals	30 (in India)	1,000
Oil shale	15	500
Tar sands	130	1,000
Hydropower	1,500	3,000

NOTE: Figures indicating present world use fail to reveal the major differences existing between countries. However, there are not yet sufficient data available to draw up such a table on a country-by-country or even region-by-region basis. Moreover, even if the contribution of particular energy source to the world's energy production is slight, it may still play an essential role for a particular country taken in isolation. For example, peat is used for generating one third of Ireland's electricity, and geothermal energy alone may produce almost all the electricity of a region or country.

Source: United Nations A/CONF.100/PC/17

FIG. EWIII-2

World hydroelectric potential. While Europe is already exploiting 59% of its total hydroelectric potential, the Third World is using only 8% of its capacity. (Source:World Energy Conference, 1980)

	Technically usable potential		Present operating capacity		Percentage of hydropotential at present harnessed
	10^{12}kWh	% world total	10^{12}kWh	% world total	
North America	3.12	16	1.13	35	36
Europe	1.43	7	0.84	26	59
USSR	2.19	11	0.26	8	12
Oceania	0.39	2	0.06	2	15
NORTH	7.13	36	2.29	71	32
Africa	3.14	16	0.15	5	5
Latin America & Caribbean	3.78	20	0.30	9	8
Asia (excl USSR)*	5.34	28	0.47	15	9
SOUTH	12.26	64	0.92	29	8
World Total	19.39	100	3.21	100	17

** It is not clear whether the Asia total includes China. According to Chinese data supplied to UNERG, China's usable potential is 1.9 x 10^{12} kWh and its present capacity is 0.05 x 10^{12} kWh. So China is using under 3% of its capacity at present.*

FIG. EWIII-3

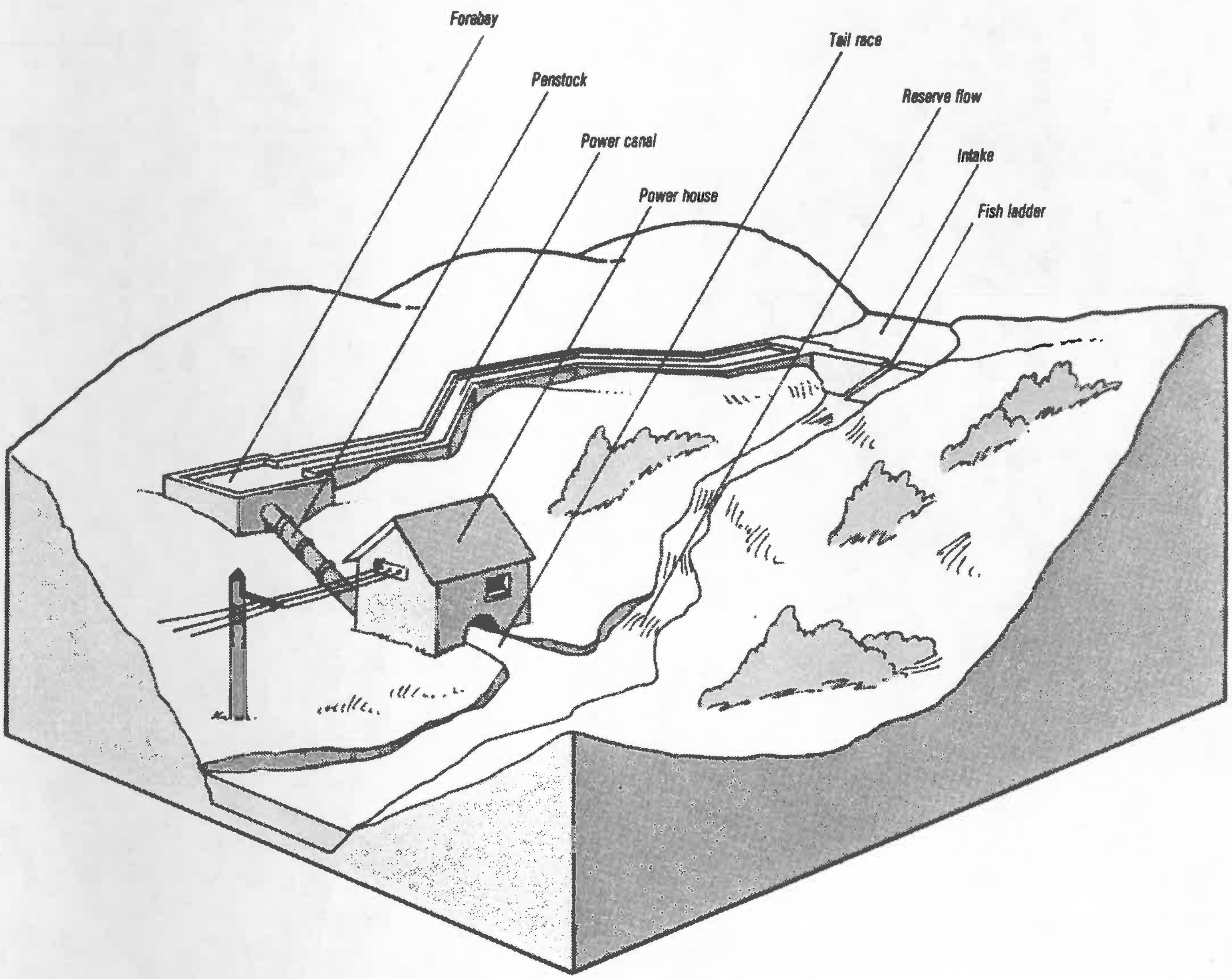

Forebay
Penstock
Power canal
Power house
Tail race
Reserve flow
Intake
Fish ladder

FIG. EWIII-4

Expected increases in electricity generated from hydropower, 1976-2020. The greatest increases are expected in the Third World and China. (Figures in exajoules: 10^{18} joules) Source: World Energy Conference, 1980.

	1976	2000	(increase 1976-2000)	2020	(increase 1976-2020)
OECD countries	3.78	5.37	(x 1.4)	7.80	(x 2.1)
Centrally-planned countries (incl. USSR and China)	0.72	2.88	(x 4)	8.70	(x 12.1)
Developing countries (excl China)	1.17	4.49	(x 3.8)	11.80	(x 10.1)
WORLD TOTAL	5.67	12.7	(x 2.2)	28.30	(x 5.0)

FIG. EWIII-5

Geothermal electrical generating capacity, 1980 and 2000 (estimated). (Some percentages have been rounded; less than 1% is shown as zero; a plus indicates a minimum figure.) Source: UNERG)

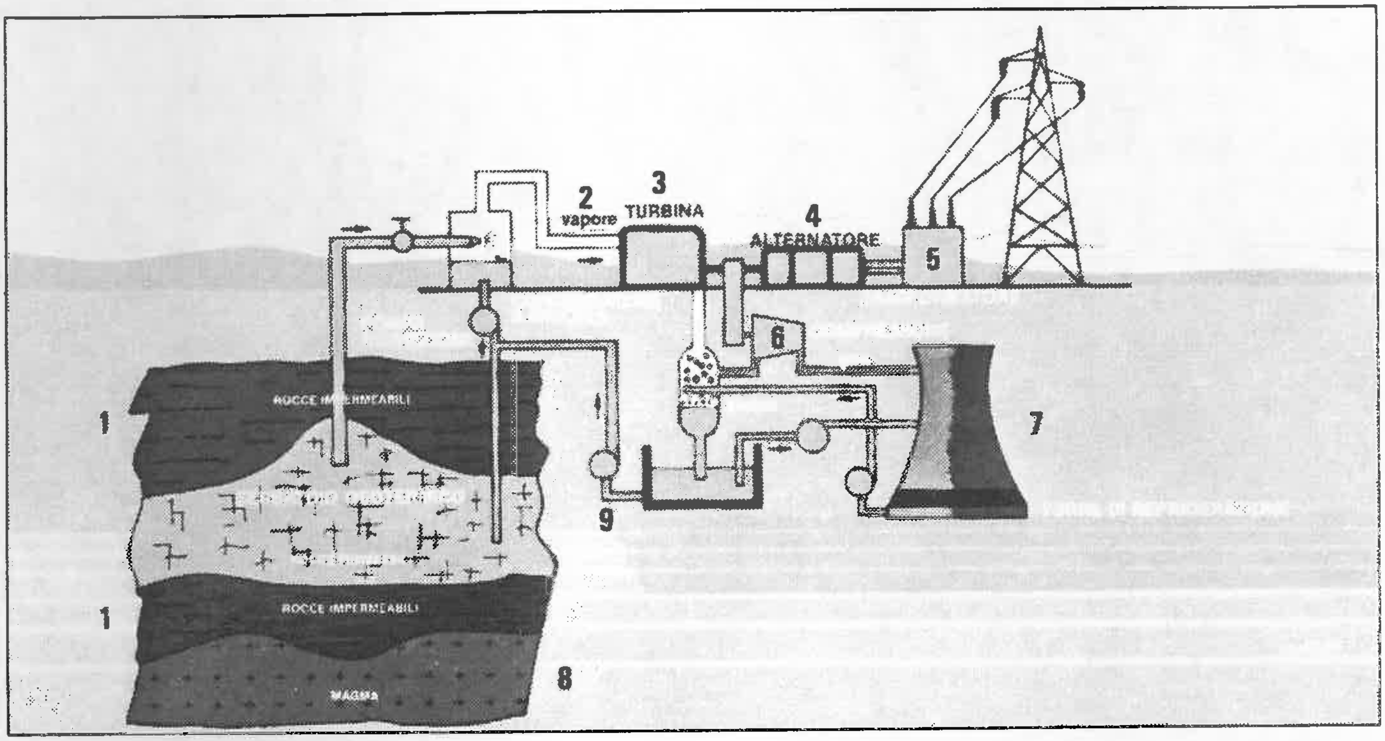
	1980		2000	
	MW	% of world total	MW	% of world total
USA	923	38	5824	33
Japan	168	7	3668+	21
Italy	440	18	800	5
New Zealand	202	8	382+	2
USSR	5	0	310	1
Turkey	0.5	0	150	1
Iceland	32	1	68+	0
France	0	0	15+	0
TOTAL NORTH	1771	72	11217	64
Mexico	150	6	4000	23
Philippines	446	18	1225+	7
El Salvador	95	4	535	3
Costa Rica	0	0	380+	2
Nicaragua	0	0	100	1
Indonesia	0.25	0	92+	0
Ethiopia	0	0	50	0
Kenya	0	0	30+	0
Chile	0	0	15+	0
TOTAL SOUTH	691	28	6427	36
WORLD TOTAL	2462	100	17644	100

FIG. EWIII-6

Installed low-temperature geothermal capacity in 1980. Nearly 100% of the bathing capacity is in Japan, Hungary, Iceland and Italy, and 97% of total capacity is installed in these four countries plus China and the USSR. (Source: UNERG)

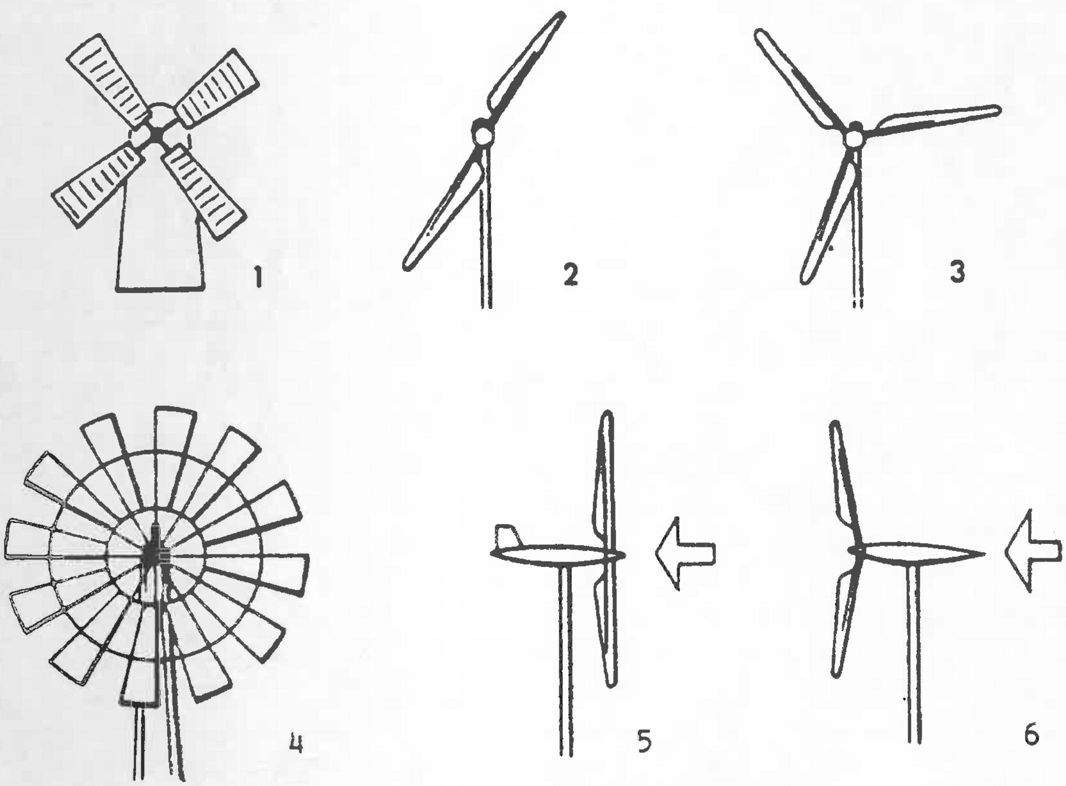
	For bathing		For other purposes		Total	
	MW	%	MW	%	MW	%
Japan	4394	82	81	3	4475	56
Hungary	547	10	619	23½	1166	15
Iceland	209	4	932	35	1141	14
USSR	0	0	555	21	555	7
Italy	192	4	73	3	265	3
China	7	0	144	5½	151	2
USA	4	0	111	4	115	1
France	0	0	56	2	56	1
Czechoslovakia	8	0	35	1½	43	1
Romania	0	0	30	1½	36	0
Austria	3	0	2	0	5	0
TOTAL	5364	100	2644	100	8008	100

FIG. EWIII-6a



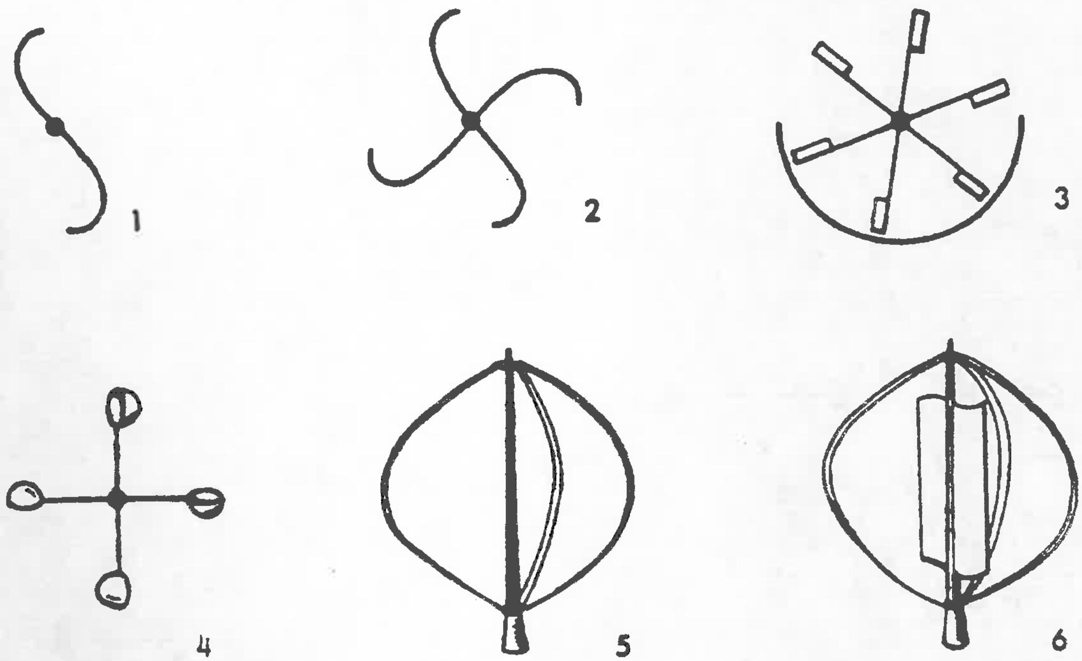
1 - IMPERMEABLE ROCKS
2 - STEAM
3 - TURBINE
4 - GENERATOR
5 - TRANSFORMER
6 - GAS COMPRESSOR
7 - COOLING TOWER
8 - MAGMA
9 - REINJECTION PUMP

FIG. EWIII-7



Horizontal axis windmills have to be twisted around to face the wind. The oldest type is the Dutch post-mill (1) which stands in its own building. Double-bladed (2) and 3-bladed (3) machines are more carefully-designed aerofoils. Over a million of the US-style multi-bladed farm windpump (4) are still in use worldwide. Upwind (5) and downwind (6) aerofoils are often used to generate electricity.

FIG. EWIII-8



Vertical axis windmills work whatever the direction of the wind. The single-bladed (1) and double-bladed (2) Savonius rotors are a well-tried design, but the flat-plate rotor (3) is easier to make, although it needs a windshield. The cupped rotor (4) is often used in anemometers (windspeed indicators). The phi-Darrieus rotor (5), or egg-whisk, was invented in France in 1927. A number of combinations of designs are now used: this one (6) is a Savonius-Darrieus rotor.

FIG. EWIII-9

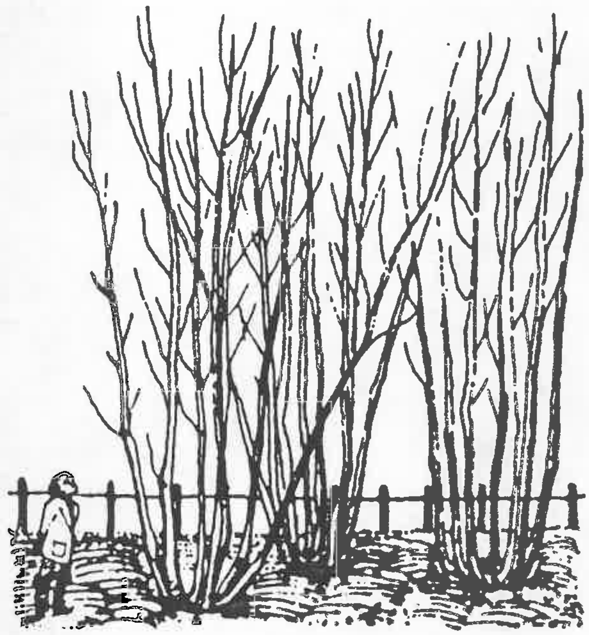
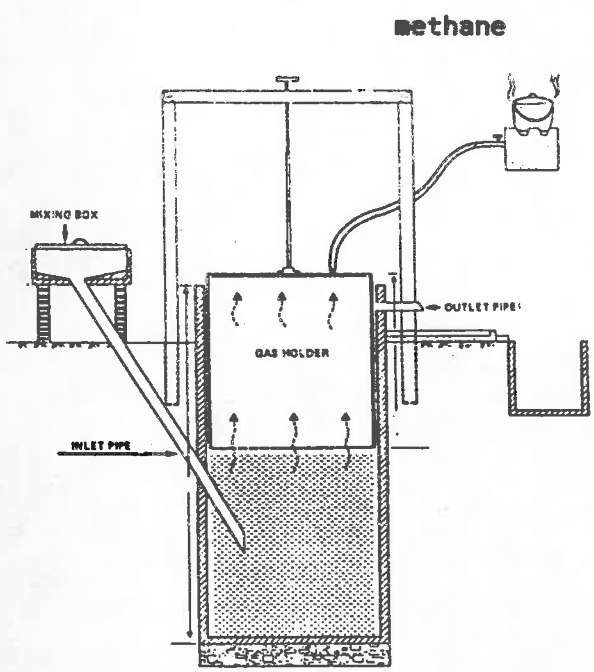
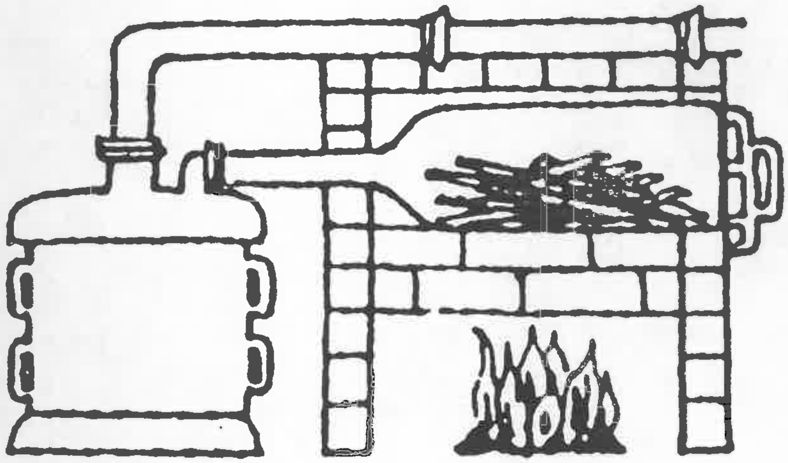


FIG. EWIII-10



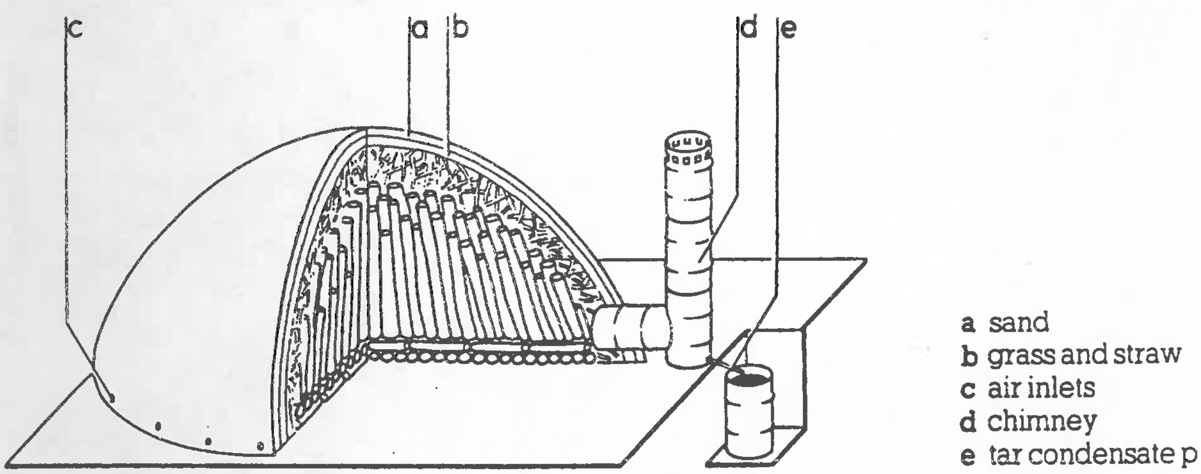
BIOGAS PRODUCTION

FIG. EWIII-11



PYROLYSIS GAS

FIG. EWIII-12



CHARCOAL MAKING

FIG. EWIII-13

FIG. EWIII-14

COMPARISON BETWEEN TRADITIONAL AND NRSE FOR THERMAL ENERGY PRODUCTION (AFTER FURLAN, MANCINI, SAYIGH)

TECHNOLOGY	CAPITAL COST $/kW	OP. TIME h/yr	ENERGY COST cents/kWh
Solar heating (san. water)	300-600	2000	1.5-3.0
Solar heating (space)	400-800	500	8-16
Solar cooking	200-300	500	4-6
Biogas (family)	500	contin.	0.6
Biogas (communities)	250	contin.	0.3
Alcohol from sugar cane	800	4000	2
Biomass (forest)	-	-	0.03-0.07
TRADITIONAL SYSTEMS			
Coal (25$/ton)	-	-	0.3
Oil (12$/barrel)	-	-	0.7

FIG. EWIII-15

COMPARISON BETWEEN CENTRAL PRODUCTION OF ELECTRICITY AND NRSE ELECTRICITY PRODUCTION (AFTER FURLAN, ET AL.)

TECHNOLOGY	POWER kW	CAPITAL COST $/kW	OP. TIME h/yr	ENERGY COST cents/kWh
Wind	1	3000-6000	2500	12-24
	5-15	1000-2000	2500	4-8
	3000	450	2500	2
Small hydro. units	0.05-10	1000-7000	4000	3-18
Photovoltaic	1	15000-30000	2000	75-150
CENTRALISED SYSTEMS				
Large hydro. units	250,000	800-1500	4000	2-4
Coal thermoel. plant	300,000	500	4000	2
Oil thermoel. plant	300,000	400	4000	3

APPENDIX 1

ENERGY UNITS

a	annum
BTU	British thermal unit - 0.252 kilocalories
Btuh	British thermal unit/hour
cfm	cubic feet per minute
ft^3/hr	cubic feet/hr
lb/hr	pounds/hour
lbm	pounds mass
m^3	cubic meter
GWh	gigawatt hour - 1,000,000 kilowatt hours
km	kilometer - 1,000 meters
kV	kilovolt - 1,000 volts
kVA	kilovolt ampere - 1,000 volt amperes
kW	kilowatt - 1,000 watts
kWh	kilowatt hour - 1,000 watt hours
MW	megawatt - 1,000 kilowatts
MB	thousand barrels - 1,000 barrels
MWh	megawatt hour - 1,000 kilowatt hours
MVA	megavolt ampere - 1,000 kilovolt amperes
tonne	metric ton - 1.1 US tons
Tpa (tpa)	tonnes per annum
TOE (toe)	tonne of oil equivalent - 39.68 million BTU (10 million kilocalories)
MTOE (Mtoe)	thousand TOE (toe) - 1,000 tonne of oil equivalent

APPENDIX 2

ENERGY EQUIVALENTS AND ENERGY UNITS

Unit of:	EQUALS								
	boe	toe	tce	GJ	KWh	kcal	Btu	HP-h	CV-h
l. of Oil Equiv. (boe)	1.00	0.14	0.20	5.80	1611.1	1385×10^{3}	5.497×10^{6}	2160.5	2190.7
nne of Oil Equiv. (toe)	7.22	1.00	1.43	41.87	11630.	10×10^{6}	39.68×10^{6}	15596.	15812.
nne of Coal Equiv. (tce)	5.05	0.70	1.00	29.3	8141.	7×10^{6}	27.77×10^{6}	10917.	11068.
gajoule (GJ)	0.172	0.024	0.034	1.00	277.7	238.8×10^{3}	0.948×10^{6}	372.5	377.7
lowatt hours (kWh)	0.62×10^{-3}	86×10^{-6}	123×10^{-6}	3.6×10^{-3}	1.00	860	3412	1.341	1.360
localorie (kcal)	0.722×10^{-6}	10×10^{-6}	14.3×10^{-6}	4.187×10^{-6}	1.163×10^{-3}	1.00	3.968	1.56×10^{-3}	1.58×10^{-3}
itish Thermal Unit (Btu)	0.182×10^{-6}	25.2×10^{-9}	36.0×10^{-9}	1055×10^{-9}	0.293×10^{-3}	0.252	1.00	0.393×10^{-3}	0.398×10^{-3}
-hour (Imperial)(Hp-h)	0.463×10^{-3}	64.1×10^{-6}	91.6×10^{-6}	2.68×10^{-3}	0.746	641.2	2544.5	1.00	1.014
-hour (Metric)(CV-h)	0.456×10^{-3}	63.2×10^{-6}	90.3×10^{-6}	2.65×10^{-3}	0.735	632.4	2509.6	0.986	1.00

TE: A tonne of oil equivalent is usually assigned a value of 10 million kilocalories. Oil with an energy content of 10 million kilocalories per tonne would have a specific gravity of about 0.90 and an API gravity of about 25. It wpuld thus be midway between distillate and residual fuel oils in both gravity and energy contents and might therefore be termed more accurately a "fuel oil equivalent". By averaging distillates and residual we obtain a ratio 7.0 barrels per tonne equivalent, which on the basis of 41.87 gigajoules per tonne equivalent (10 million kilocalories) yields 6.0 gigajoules per barrel of oil equivalent. The barrel of oil equivalent defined as 5.8 gigajoules is therefore a slightly "lighter" fuel, equal to 42.7 gigajoules per tonne and 7.22 barrels per tonne of oil equivalent.

APPENDIX 3

APPROXIMATE NET HEAT CONTENTS OF COMMONLY USED FUELS

	EQUALS			
	Bbls of oil equivalent	Tonnes of oil equivalent	Tonnes of Coal equivalent	Gigajoules (10^9 joules)
1 TONNE OF:				
Coal	5.05	0.70	1.00	29.3
Lignite	2.01	0.28	0.40	11.7
Peat	2.53	0.35	0.50	14.7
Coke	4.91	0.68	0.97	28.5
Charcoal, Briquettes	4.98	0.69	0.99	28.9
Firewood (air dried)				
Pine	2.34	0.32	0.46	13.6
Hardwood	1.60	0.22	0.32	9.3
Bagasse (30% moisture)	2.17	0.30	0.43	12.6
Agricultural Wastes	2.00	0.28	0.40	11.6
Dung Cakes	1.53	0.21	0.30	8.9
Nut Shells	3.40	0.47	0.67	19.7
Dry Straw	3.02	0.42	0.60	17.5
LNG	9.10	1.26	1.80	52.8
LPG	7.79	1.08	1.54	45.2
Gasoline	7.59	1.05	1.50	44.0
Kerosene/Jet Fuel	7.43	1.03	1.47	43.1
Gas Oil/Auto Diesel	7.36	1.02	1.46	42.7
Industrial Diesel	7.29	1.01	1.44	42.3
Residual Oil	7.07	0.98	1.40	41.0
Asphalts	7.22	1.00	1.43	41.9
Lubes				41.4
Petrochemical Feedstocks	7.59	1.05	1.50	44.0
Petroleum Coke	6.00	0.83	1.19	34.8
Ethyl Alcohol	4.76	0.66	0.94	27.6
Methyl Alcolol	4.10	0.50	0.71	20.9
1 BARREL OF:				
LNG	0.60	0.08	0.12	3.5
LPG	0.67	0.09	0.13	3.9
Gasoline	0.90	0.12	0.18	5.2
Kerosene/Jet Fuel	0.97	0.13	0.19	5.6
Gas Oil/Diesel	1.00	0.14	0.20	5.7
Industrial Diesel	1.02	0.14	0.20	5.9
Residual Oil	1.05	0.15	0.21	6.1
Asphalts	1.21	0.17	0.24	7.0
Lubes	1.00	0.14	0.20	5.8
Petrochemical Feedstocks	0.90	0.12	0.18	5.2
Petroleum Coke	1.29	0.18	0.26	7.5
Ethyl Alcohol	0.60	0.08	0.12	3.5
Methyl Alcohol	0.47	0.06	0.09	2.7
1000 M^3 OF:				
Natural Gas	6.00	0.83	1.19	34.8
Town Gas	2.88	0.40	0.57	16.7
Producer Gas	1.02	0.14	0.20	5.9

NOTE: The figures in this table are net heating values (reduced from gross values by the latent heat of vaporisation of water formed in combustion). These figures, commonly used in Europe, are appropriate representations of heat release in furnaces, kilns and boilers. In the United States the practice is to use gross heats of combustion. Some typical values for the ratio of net to gross are as follows:

Fuel	Net/Gross Ratio
Natural Gas	0.90

PART I: EXTRACT FROM "ENERGY AND RURAL WOMEN'S WORK: CRISIS, RESPONSE AND POLICY ALTERNATIVES", BY E. CECELSKI, IN INTERNATIONAL LABOUR REVIEW, VOL. 126, NO. 1, JANUARY-FEBRUARY 1987.

PART II: EXTRACT FROM "MOBILIZING RENEWABLE ENERGY TECHNOLOGY IN DEVELOPING COUNTRIES: STRENGTHENING LOCAL CAPABILITIES AND RESEARCH", WORLD BANK, JULY 1981.

PART III: EXTRACT FROM "NATIONAL APPROACHES TO THE ACQUISITION OF TECHNOLOGY", DEVELOPMENT AND TRANSFER OF TECHNOLOGY SERIES NO. 1, UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION.

PART I

Energy and rural women's work: Crisis, response and policy alternatives

Elizabeth CECELSKI *

I. The crisis

More than a decade ago the world entered an era of higher energy costs. In 1983 the World Bank estimated that developing countries needed to invest about 4 per cent of their GDP in energy annually, or altogether US$130,000 million, in order to meet projected needs over the next ten years (IBRD, 1983, pp. xviii-xix). Even with the lower oil costs of late, such an investment still poses a very difficult problem for most developing economies, weighed down as they are by the world recession, deteriorating terms of trade for their raw materials exports, massive debts and recently, in much of Africa, drought and famine. And all developing countries, including many oil exporters, will need ever larger amounts of energy in the future owing to increasing population growth, urbanisation and industrialisation.

Up to now the impact of higher energy costs has been cushioned by large reserves of "free" wood and other biomass fuels (animal dung, crop wastes) from the fields and forests of rural areas, though at the cost of deteriorating living and working conditions in the rural subsistence sector. By the year 2000, however, more than 2,000 million people in developing countries will be suffering from an acute scarcity of fuelwood (FAO, 1981). The distinction between "free" traditional woodfuels and expensive "modern" fuels is already becoming meaningless in many Third World cities: woodfuels for cooking today are no cheaper, and sometimes even dearer, than kerosene or gas. There is already a huge "overhang" of household demand for these modern fuels, and higher woodfuel prices and rising incomes will obviously lead either to increased fossil fuel imports (or increased use of indigenous resources) or to rationing. Many governments are looking to biomass and wood cultivation and to crop residues as new sources of energy for modern industry, transport and household use, such as fuel alcohol and producer gas.

In most developing countries the household sector is still the largest single energy consumer – and the poorer the country, the truer this is. As table 1 shows, in lower-income countries such as Burkina Faso, Ethiopia and Nepal the household sector accounts for more than 90 per cent of total energy consumption. The share of biomass fuels in the household sector is similarly related to the level of economic development but remains at over 80 or 90 per cent in most countries.

Deforestation and even desertification are the most serious consequences of this unseen reliance on "free" biomass fuels. But agricultural productivity begins to fall well before these "natural" disasters strike. The growing use of tree, crop and animal residues for fuel deprives the soil of recycled nutrients and thus reduces crop yields and also agriculture's capacity to support livestock, thus diminishing the draught power available to farmers. Men are forced to leave the land in search of seasonal work or work in the towns in order to supplement rural incomes, further reducing the labour inputs available for agriculture. These "environmental refugees" swell urban populations and intensify the pressure on rural food and biomass resources, while food production declines.

Hardest hit by this crisis are rural women. Women are largely responsible for subsistence food production and must increase their own labour inputs as productivity decreases, while often forfeiting the help they need to receive from their menfolk, in such tasks as land clearing and ploughing, as a result of migration (an avenue often closed to women for social reasons). As the quality and quantity of forest and water resources decline, the time and effort that must be devoted to fuel and water collection, two of women's traditional tasks, also increase. The possibility of obtaining "minor" wild forest and field products to supplement family nutrition and incomes, e.g. through food processing for sale, is excluded. Women have little choice but to work more (and to use child labour to help them), cut down on family living standards and try to squeeze more output and income out of the land, thereby often contributing to the destruction of the ecological base – a vicious circle.

These are among the major findings of an ILO research project (supported by the Netherlands Government) on energy and rural women's work in several countries in Asia, Africa and Latin America. The ILO's interest in rural energy arises from its concern that sufficient energy supplies should be available both for meeting minimum basic needs and for promoting economic development and rural employment (ILO, 1982). Since 1982 comparative country studies have been made on the effects of the rural energy crisis on rural women and households in Peru, Ghana, Mozambique, India and Indonesia.[1] Multidisciplinary national teams carried out action research in several villages representing different ecological regions in each country. Information on the time use of family members, fuel search and use, and food consumption was collected through household sample surveys during the rainy and dry seasons and through detailed observation of individual women in each village. Group discussions and interviews were used to obtain more qualitative information and opinions as

Table 1. Household energy consumption and biomass[1] fuels in national energy balances, selected countries

Country	Year	Household energy consumption as % of total energy consumption	Biomass fuels as % of household consumption
Indonesia	1978	...	84.0
Nepal	1980/81	94.0	98.7
Thailand	1983	29.3	84.8
Burkina Faso	1983	92.7	97.7
Ethiopia	1982	92.8	99.5
Ghana	1985	72.0	94.0
Mozambique	1980	76.4	98.7
Senegal	1981	67.4	93.2
Tanzania (United Rep.)	1981	85.0	98.8
Zambia	1980/81	45.6	91.8
Zimbabwe	1980	30.0	85.4
Ecuador	1984	32.8	30.5
Peru	1981	38.6	62.4

[1] For purposes of this table "biomass" means traditional, non-commercial fuels.

Source: UNDP/World Bank Energy Sector Assessment Program reports with the exception of the figures for Mozambique which are taken from P. O'Keefe and B. Munslow (eds.): *Energy and development in southern Africa*. SADCC country studies, Part II (Stockholm and Uppsala, Beijer Institute and Scandinavian Institute of African Studies, 1984).

well as to catalyse group reflection on the fuel problem and possible solutions.

II. The household response: Survival strategies

These country studies show that, confronted with changes in fuel and biomass availabilities, rural households are being forced to make various adjustments that adversely affect their living standards, work and consumption. The adjustments produce negative effects on working patterns; on family nutrition and health; and on the environment, agricultural productivity and incomes. Some aspects of the urban fuel crisis and rural-urban linkages are also relevant here.

Working patterns

Although the division of agricultural and other tasks between men and women varies considerably from one region to another, in general men tend to have greater access to the cash economy and public life and to perform primary activity. Women's activities revolve more around the subsistence economy, family food production and household maintenance. These activities, while essential to family survival and welfare, are typically unpaid – although women's "secondary" activities (such as food processing) may make a substantial contribution to family incomes. The ILO country studies confirm this general pattern.

The double – or rather triple – burden on women of household, family agricultural and income-earning work is shown in table 2. In these examples women's work in agriculture ranges from a low of 1.3 hours daily (owing to the drought) in a savannah village in Ghana to a high of four hours in the Peruvian sierra, where the women work on family plots and as wage labourers in co-operatives or on state or private farms. Non-agricultural income-earning work, such as crafts, trade and food processing, ranges from a low of 0.1 hours in Mozambique, where few opportunities for such work exist, to a high of 6.3 hours in a Ghanaian village, where women's main occupation is fish smoking. Household maintenance – cooking, fuel and water collection, cleaning and child care – takes up the largest proportion of women's time in virtually all the villages studied. On average women work about the same number of hours as men in agriculture, while men work only slightly more hours than women in non-agricultural activities. Almost all the household tasks are performed by women alone. This triple burden means that women work considerably longer hours than do men, between 11 and 14 hours daily in the countries studied as compared with between eight and ten hours for men.

Two of the most time-consuming activities for women in these villages are fuel collection and cooking. The total time spent on them ranges from 1.5 hours daily in an irrigated village in West Java, where new agricultural wage opportunities for women seem to have replaced their household activities, to five hours in a savannah village in Ghana. These energy-related activities take up between 13 and 36 per cent of women's total work time. A major activity for women in most of the villages in fact is *cooking* – up to 34 per cent of women's daily workload; an exception is Mozambique where, because of the severe food shortage at the time of the study, only one meal per day was prepared.

Men, women and children have distinct roles in fuel supply and use. Interestingly, the division of labour in fuel collection activities varies little by region. Men usually cut down trees to be used for household fuel. The collection of "minor" fuels such as branches, bushes, dung and crop residues, on the other hand, is frequently done by women in conjunction with other activities such as medicinal herb gathering, or on their way back from work in the fields. Partly for this reason, women in these villages typically spend less time on fuel collection alone than on cooking, in most cases no more than an hour or two. More important, perhaps, is the change in women's work patterns when fuel gathering can no longer be combined with other work but

Table 2. A rural woman's work is never done... (hours per day)

Country	Agricultural work [1]	Non-agricultural work [2]	Fuel collection and cooking	Other [3]	Total hours worked
Indonesia					
Irrigated village	2.9	0.2	1.5	6.9	11.5
Upland village	3.1	0.5	2.4	6.0	12.0
India					
Average of five villages	3.9	4.0	4.8	0.9	13.6
Ghana					
Savannah village	1.3	2.7	5.0	5.0	14.0
Fishing village	2.0	6.3	3.6	2.1	14.0
Forest village	3.8	0.3	4.1	5.8	14.0
Mozambique					
Average of four villages	3.1	0.1	1.8	9.0	14.0
Peru					
Coastal desert	1.4	2.0	2.2	5.6	11.2
Sierra	4.0	1.0	3.8	2.4	11.2
High sierra	4.0	2.0	2.9	2.8	11.7

[1] Family subsistence, wage employment and livestock raising. [2] Crafts, food processing and trade. [3] Cleaning, child care, social, community and religious activities; for Ghana, travel time is also included here.
Source: See note 1 at the end of the article.

Since women and children are responsible for collecting residue fuels, their workload is increased when these fuels have to replace others that are becoming scarce. Residue fuels include twigs and branches, bushes, thorns and weeds, crop stalks, pods and roots, animal dung, and even paper and plastic trash. Many residue fuels not only take more time to gather in sufficient quantities (the relative calorific value being lower) but also require more time and attention when they are used since they burn quickly and the fire must be constantly tended. When women and children regularly collect residue fuels, one may conclude that fuel scarcity has reached a level that is probably severely affecting the environment as well as family welfare. On the other hand, commercialisation of household fuels, whether woodfuels or "modern" fuels, is a sign of both fuel scarcity and the availability of cash incomes.

Nutrition and health

When families are really hard pressed, food production and cash earning take precedence over women's household tasks such as cooking and fuel and water collection, even though these are also essential for family welfare. The traditional "hungry season" before the harvest is a crucial period: food deprivation is acute at the very time when all the adults have to work the hardest. When more time has to be spent on particular tasks, whether in farming or in fuel collection, women's other work suffers. The case studies suggest that the total time spent on food preparation, including fuel gathering for cooking, may be limited simply because other subsistence activities demand more time. In villages where women had to spend more time on fuel collection, they spent less time on cooking. This, however, can result in a lower nutritional level.

To spend less time cooking is an extreme reaction to a fuel shortage. Generally, less fuel per head is used in those villages that experience fuel supply difficulties, although the amount also varies according to diet and other factors. Staple foods such as beans and whole grains have to cook a long time before they are edible (or even safe to eat, in the case of legumes). Cooking fewer meals, eating cold or reheated leftovers, eating more snacks or processed foods and even changing diets have been reported as fuel-saving devices in areas suffering from an acute shortage of fuel, such as the Sahel, Haiti, Mexico and Nepal.

In most of the countries studied (especially in drought-stricken Africa) the lack of food was so great that fuel shortages played only a minor role in determining diets. Many households had only two meals a day or sometimes only one. The quantities and types of foods cooked play an important part in determining fuel use per head. Coastal villages in Peru and Ghana where fish consumption is high use much less cooking fuel than inland villages relying on hard staples such as maize, cereals, potatoes and cassava. This suggests that studies on fuel-saving methods should take a hard look at foods requiring high energy inputs.

Family welfare can also suffer from the loss of products gathered from forests. In subsistence economies uncultivated areas provide food, medicines, building materials, tools and utensils. Foods gathered from these areas, mainly by women, are often an important nutritional supplement. Even arid and semi-arid savannahs and deserts can provide a variety of wild produce, which are especially important as a fallback during drought.

Wood and charcoal, let alone fossil fuels, are rarely purchased by these rural households for cooking, except for income-generating uses. Most poor households have had to switch increasingly to cooking with residue fuels since they cannot afford either wood or fossil fuels. This is not to say that they do not value and need "modern" energy sources such as kerosene and gas; in fact they often spend a considerable amount of time in searching for supplies of scarce kerosene. In the many countries which have found it necessary to limit imports and ration supplies even in the cities, very little kerosene finds its way to the countryside. Not only kerosene and other petroleum products but the equipment needed to use them (stoves, gas bottles) are expensive and difficult to find in rural areas because of high transport costs and small dispersed markets. However, where life styles are changing and incomes are rising rural households also wish to adopt more convenient cooking fuels, and indeed may need to do so in order to provide nutritious meals in keeping with new work and school patterns.

Kerosene was used only for lighting in most of the villages studied, but even so that use absorbed an appreciable proportion of rural household budgets. Table 3 shows that between 5 and 20 per cent of household expenditures went on fuel (mainly kerosene), while the food budget varied between 50 and 91 per cent. Because of the households' small cash incomes even this minor use of a commercial fuel has already affected food and other expenditures; and further commercialisation of household fuels is bound to make matters worse unless rural incomes increase.

Water and heating are also "luxury" uses of fuel that are frequently curtailed when fuel is scarce. However, washing is essential for health and heating is often essential for survival. In cold mountainous regions such as the Andes, Himalayas and Ethiopian highlands as much fuel is used for heating as for cooking, which may be one of the reasons why these regions suffer so much from fuel scarcities.

Besides taking more time to gather and use, residue fuels are also smoky and inefficient. Storing the large quantities needed in a dry place is practically impossible, especially in the rainy season. Even poisonous weeds are used for cooking by the poor in some of the villages studied (*retama* in Peru, *basoothi* in India). Rooms were quickly filled with smoke by the inadequate combustion of damp, low-quality fuels. The WHO has begun to document the serious health effects (especially eye and respiratory diseases) of lengthy exposure to emissions from biomass fuels in smoky kitchens (WHO, 1984).

The heavy workload of manual tasks imposed on women also affects their health. A study carried out in Karnataka State in India calculated that women's calorie expenditures were higher than those of men and that energy expenditures on domestic tasks were higher than on agricultural work (Batliwala, 1982). Many of these tasks (gathering firewood, fetching water, cooking, etc.) could be done mechanically or made more efficient through the use of alternative technologies and energy resources.

Little attention has been paid so far to the "working conditions" of female fuelwood collectors. Forest workers are provided with special equipment for harvesting trees, yet women collecting fuel for subsistence do the job with their bare hands and primitive tools. Loads weighing 25 to 35 kilograms on average (some were said to weigh as much as 80) are carried for miles on end and very often exceed the maximum weights allowed by the country's labour legislation (most legislation prohibits the carrying by women of loads weighing over 20 kilograms) (ILO, 1966).

The environment, agricultural productivity and income

A typical Peruvian valley in the Andes is graced by eucalyptus trees destined for poles and pit props for mines while the women from the villages

Table 3. Distribution of household expenditures among food, fuel[1] and other items in four countries (%)

Village	Food	Fuel	Other	Total
Indonesia				
Irrigated village	50	10	40	100
Upland village	63	5	32	100
India				
Average of five villages	87	9	4	100
Ghana				
Savannah village	85	5	10	100
Fishing village	81	8	11	100
Forest village	91	7	2	100
Peru				
Coastal desert	69	20	11	100
Sierra	71	5	24	100
High sierra	68	8	24	100
Average of 13 villages	78	9	13	100

[1] Fuel expenditures almost exclusively kerosene (for lighting), except in the coastal desert village in Peru.

Source: As for table 2.

scour the hillsides for bushes and roots for fuel. The Green Revolution in Malari (India) has left the landless and semi-landless without communal forests and with few fuel-producing resources of their own, so they use animal dung for cooking fuel instead of fertiliser for their meagre lands. Women in drought-stricken rural Ghana "mine" their fallow land for charcoal making. Are these women destroying the environment and creating a fuel scarcity? The principal causes of deforestation and fuel scarcity in the villages studied were population growth and the clearing of forests for agriculture. Ironically, deforestation often results in lower agricultural productivity and hence makes it necessary to expand cultivation still further. Present policies have failed on the whole either to increase agricultural productivity on existing cleared land or to generate enough off-farm or urban employment to absorb surplus agricultural labour. Land settlement schemes involving massive clearing of forest areas have often been the response of governments seeking an outlet for growing populations. Because they need to export raw materials in order to earn foreign exchange, many developing countries have also been forced to sell their tropical forests cheaply.

The breakdown of traditional systems of common property management marginal agricultural areas, for example much of the Sahel and Baluchistan (Pakistan). Fast-growing cities and towns and expanding rural industries have also depleted surrounding forests, where the trees have been felled for high-quality wood and logs rather than for the deadwood and minor fuels that rural households use for cooking. Refugee camps and new communal villages, in turn, cast smaller versions of the "urban shadow" on nearby forests.

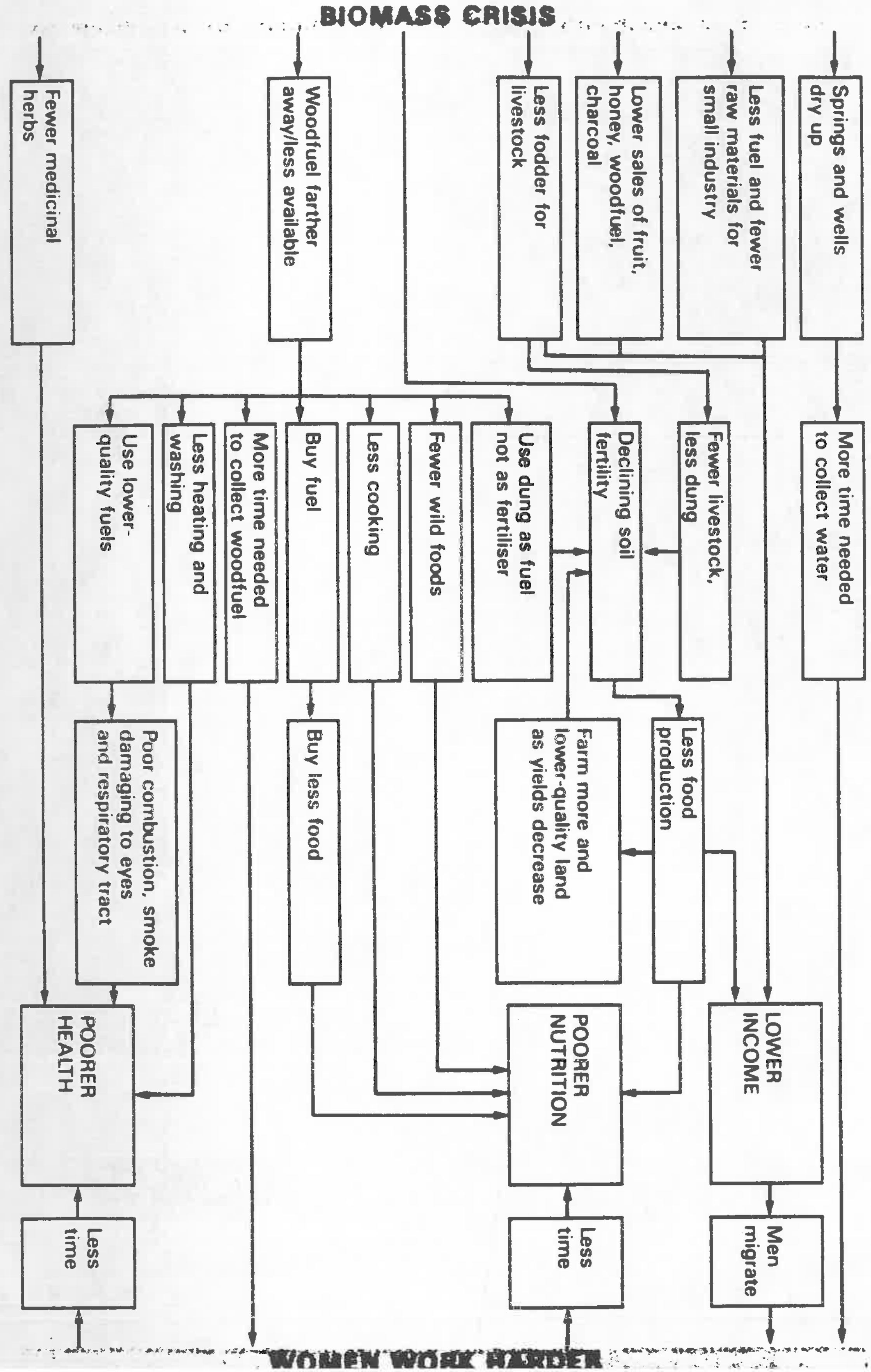
The damage caused to the environment by rural women in gathering a few twigs and residues for cooking is insignificant by comparison. It is hardly surprising that women in the villages studied saw little relation between their own actions and environmental deterioration. People usually feel that the encroachments being made on the environment are the work of external forces, which they and their communities have no power to control, any more than they can control fuel scarcity. Nor is any need felt for specific action to protect the supply of biomass, since fuel has always been considered a "free" good. In some of the Indian villages studied the women said that their fuel problems had been caused by the outside contractors who had come to cut down the trees and by the government restrictions placed on their use of the forest – things they could do nothing about. At the same time the pressures on the environment have had consequences for people's lives of far greater scope than the decline in fuel supplies. In Ghana, for example, the introduction of new cash crops such as cocoa has increased population pressures in settled areas and more land has been privatised. This in turn has restricted women's access to land and their ability to produce food as well as fuel in many cases. Moreover, the struggle of the poor simply to stay alive is so desperate in some countries that long-term fuel supply is often immaterial to them. In most of the countries studied food consumption at the time was below the minimum considered necessary for human survival. Poor women will therefore only feel they have a stake in efforts to tackle energy problems if they lead to an improvement in nutrition and income as well.

Women are hit the hardest by the negative effects of environmental deterioration on incomes and welfare. The most important effect is the long-term decline in agricultural productivity and hence in food production. This means that more land must be brought under cultivation and, since the soil is often unsuitable for farming, leads to still further deterioration. In the western Sudan, for example, the traditional practice of crop rotation has been abandoned on account of the growing population and low rainfall, causing soil erosion and lower land productivity. To compensate for the declining yields, women are forced to cultivate their millet or sorghum over larger areas and to work harder to achieve the same output. Such expansion further accelerates the process of soil erosion and prevents natural regeneration (Berar-Awad, 1985, and Ibrahim, 1982).

While more attention has recently been paid to the relationship between such "natural" disasters and human actions (Wijkman amd Timberlake, 1984), the logical connection between the food-fuel-water crisis and women's central concerns and activities is only beginning to be made (see, for example, Sen and Grown, 1985). The links between the two are illustrated in the figure showing the effects of the biomass crisis on rural women's work and basic needs. Given the sexual division of labour in the energy use and supply system as well as in agriculture, women's activities are affected more than men's work by environmental deterioration. As we have seen, not only is family farming – which is done mainly by women – becoming more difficult and less productive but women's household tasks – fuelwood collection, water fetching and cooking – are also becoming more burdensome. Furthermore, migration of male labour in search of jobs was an important phenomenon in all the villages studied. In many of them more than half the households were, in practice, headed by women for a good part of the year. If food production depends primarily on women's work, it is bound to fall sharply in areas suffering from ecological decline, and especially drought, unless more help is provided to improve their productivity.

In their search for cash income as the biomass system becomes less able to support a subsistence economy, many women in these villages are taking up low-productivity and low-wage crafts, agricultural wage employment when it can be found (at wages often half those of men) and at times even migration. In the countries studied women's contribution to household cash income ranged from one-third in some Indian villages to nearly 80 per cent during the dry season in Ghana. In relatively commercialised rural economies like Ghana and Peru women often have several sources of income, alternating between them seasonally and as opportunities arise. In Mozambique and Indonesia, on the other hand, women have fewer off-farm employment opportunities than men – being mainly restricted to agricultural wage employment – since at least seasonal migration is necessary to take advantage of most. These women make a larger contribution therefore in the form of subsistence production. In all these countries women's contribution to food production is high.

Many of women's key income-generating activities such as food processing and snacks (Indonesia), beer brewing (Peru) and fish smoking (Ghana) are fuel-intensive and the difficulty of procuring adequate low-cost fuel supplies has in many cases made production problematic. In some villages a division of labour among women in the processing of time- and energy-intensive foods has spontaneously developed. In a coastal village in Peru nearly every woman produces *chicha* beer both for sale and for home consumption at least once a week, but at other times she buys the beer from other women producers. In Ghana a variety of processed and semi-processed foods are prepared and marketed by different women, so that one woman may make and sell *fufu* (a cassava dish) while buying soup or smoked fish from other women to make up a complete meal. Partly for this reason (and because of the drought), expenditures on food in Ghana are extremely high (80-90 per cent of total spending). In cities such practices are often carried further by commercial bakeries or, as in Lima, the communal cooking of


BIOMASS CRISIS
Fewer medicinal herbs
Woodfuel farther away/less available
Less fodder for livestock
Lower sales of fruit, honey, woodfuel, charcoal
Less fuel and fewer raw materials for small industry
Springs and wells dry up
Use lower-quality fuels
Less heating and washing
More time needed to collect woodfuel
Buy fuel
Less cooking
Fewer wild foods
Use dung as fuel not as fertiliser
Declining soil fertility
Fewer livestock, less dung
More time needed to collect water
Poor combustion, smoke damaging to eyes and respiratory tract
Buy less food
Farm more and lower-quality land as yields decrease
Less food production
POORER HEALTH
POORER NUTRITION
LOWER INCOME
Less time
Less time
Men migrate
WOMEN WORK HARDER

meals in poor neighbourhoods. If they were promoted on a bigger scale significant savings in both women's time and their fuel use could be made. But it would be necessary to ensure that poor women themselves earn cash from the commercialisation of processed foods for otherwise they might be unable to afford to make or buy these foods at all. This seems to have happened to some extent in West Java where, although numerous snack and processed foods (e.g. *tofu*) are marketed on a larger scale, they are made available to poor families usually only as payment in kind or meals provided by employers.

Woodfuels and other "minor" forest products such as honey, flowers, seeds, leaves and wild fruits are critical to survival when agriculture fails or supplementary income is needed. Wood itself is the basis of much small industry and other forest products can also be sold directly or processed to increase their value, thus providing employment and income. Some 30 million people in India alone are estimated to derive part of their livelihood from forests (Kulkarni, 1983). In the rural areas studied wood collection and charcoal making, transport and marketing are an important source of income for many rural women and men, especially in Africa where rationing and shortages of fossil fuels have kept the cities reliant on woodfuels. The profitability of this market makes plantations for woodfuel processing near cities and towns a promising rural income-earning activity, provided it can be so organised as not to damage the environment and to ensure regeneration. Lessons learned from past experience with other cash crops should be heeded, however, so as to avoid mistakes that harm the poor's welfare, such as displacement of food crops, concentration of land and transfer of resources from women to men. Food production has been adversely affected mainly by "energy crops" such as sugar-cane for alcohol production, though similar harm has been caused by eucalyptus plantations for woodfuel in India.

Here it may be worth adding that the urban poor are probably suffering even more than the rural poor from the effects of fuel scarcity since their incomes have not kept pace with rising prices and they cannot fall back on subsistence production or their own labour in residue fuel gathering. A recent survey found that in Addis Ababa more than two-thirds of the cash income of the lowest income group was spent on cooking fuel (ILO, 1986b). Many of the fuel-saving practices that had been adopted by the poor in this survey had adverse effects on nutrition and health, and these were far more evident than in rural areas – cooking less, reheating, and eating cold food. Some poor households were even using residue fuels dangerous to their health.[2] Because they cannot afford the kind of stoves needed to burn more efficient fuels the poor continue to rely on woodfuels even though their cost (per unit of delivered energy) in most Third World cities today is higher than that of kerosene, gas or electricity. Yet it is the latter fuels that official subsidies often favour. Measures are urgently needed to enable urban poor households to meet their minimum basic energy needs.

III. Policy and project approaches

The findings of the ILO country studies reviewed here raise questions about the effectiveness of many current energy policies and projects and point to some possible alternative approaches. In this section we first discuss how energy can serve as a starting-point for addressing poor people's priority concerns and then describe a participatory approach to project design and implementation in line with these priorities. Strategies combining energy and rural development objectives are then suggested in three areas: managing energy demand and improving family welfare through better household fuel planning; increasing energy supplies while improving rural biomass resources and agricultural productivity; and using energy to increase women's productivity and their incomes.

Energy as a starting-point for rural development[3]

In highlighting the interdependent nature of basic human needs, including energy, the ILO country studies show that the pressure on women's time has greatly increased because of the growing scarcity of accessible woodfuel, together with the loss of food production and income sources resulting indirectly from deforestation.

Yet in most of the villages studied women did not regard woodfuel and cooking efficiency as top priorities. Their immediate preoccupation is the need for quick solutions to desperate food and income deficits. First of all, then, it is essential to help poor women understand the causes of these problems and to gain more control over resources that can provide their families with securer and higher levels of food and income. The need for locally conceived solutions and approaches is borne out by the great diversity of the ecological and other circumstances of the villages, even within the same country.

This does not mean of course that energy supplies are not important to these women. Energy is a very effective starting-point for addressing rural women's priority concerns with food, income and time saving. A schema of three different stages of environmental and socio-economic degradation can be used to put the women's priorities in these villages into perspective (table 4). Stage I is characterised by a biomass-rich subsistence economy; stage II by a natural resource system under pressure; and stage III by an advanced degree of ecological deterioration. Each stage corresponds to a particular priority for energy-related interventions. While conceptually these stages are separate, in practice more than one strategy may be needed simultaneously since many of the villages have characteristics of more than one stage.

In *stage I* signs of degradation are absent. Tree cover provides nitrogen fixation and mineral retention to the soil, while natural springs and rain provide water; agriculture is based on long fallow periods or even shifting cultivation. Access to many types of high-quality woodfuel is free, on

Table 4. Energy shortages and policy priorities at different stages of environmental and socio-economic degradation[1]

Stage	Fuel access/types	Labour time	Income	Agricultural productivity and nutrition	Migration	Policy priority
I	Free access to high-quality wood	Minimal	Forest-based industries and trade, food processing still viable	Little erosion. Nutrition based on a variety of locally cultivated and gathered products	Minimal	*Energy for labour and time saving* to increase efficiency and productivity in specific tasks, e.g. improved animal traction for water lifting, hydro grain milling, better drying for fish and herbs, more efficient beer brewing
II	Access limited and increasingly privatised. Type of fuel used corresponds to income level; the poor mostly use residue fuels being unable to afford more convenient ones	More time spent on fuel gathering, cooking, water collection and agriculture	Forest-based industries and incomes declining	Falls as a result of erosion, diversion of organic matter to fuel. The rich take control of best lands and other resources. Diets depend increasingly on purchased foods	Male migration becomes an economic necessity for poor households	*Energy for cooking and rural employment* to save time and raise incomes, e.g. through energy and resource-based income activities
III	All high-quality fuels commercialised and severe penalties imposed for encroachment on private resources	Satisfaction of basic needs alone requires all household time, with negative effects especially on women's health	No natural resource-based or fuel-intensive industries or employment	Yields of staple crops fall dramatically. Food from relief or purchase. Nutrition and health poor	Out-migration of "ecological refugees" to cities	*Energy for reclaiming waste lands and generating incomes*, e.g. through public forestry and infrastructure works

[1] Concept based on a schema in Newcombe, 1984.

common land or individual plots. Gathered foods and forest products are important in artisanal production and are sold and traded for income. Forest products are also available for housing construction and other uses and forests are a source of food, as well as fodder, especially useful during droughts and the "hungry season". Medicinal plants are widely used and there is sufficient fuel for heating and water boiling. Nutrition and health are sustained by a variety of locally produced items. Male migration is minimal since agriculture and small industries based on local resources provide adequate subsistence.

Energy for labour and time saving is nevertheless needed even in this relatively biomass-plentiful system. More food, easily accessible water and some cash income are frequently needs that could be met through a locally appropriate energy source. Improved animal traction for water lifting, small hydro grain milling, better drying methods for fish or other foods, and more efficient beer brewing are some possibilities. The proper choice depends on a clear analysis of women's existing activities and time use and of locally available non-human energy sources that could increase the efficiency of these activities.

Ecological disequilibria and resource limitations are inherent in *stage II* as loss of tree cover and use of animal dung and crop residues for fuel decrease soil fertility. Finding fodder for animals becomes a problem. As the amount of arable land becomes insufficient for year-round subsistence, permanent or seasonal male labour migration begins, adding to women's work burden. Living trees are felled for fuel by the well-off, but branches and twigs, bushes and residues become the major cooking fuels for the poor. Access to private, state and communal lands is controlled. Fuel entitlements may be tied to employment contracts or depend on kin or other social relationships. Households with enough cash switch to more convenient charcoal or fossil fuels. The amount of time that women devote to the preparation and use of low-quality fuels increases. Sale of fuelwood and charcoal making become important income-earning activities. But other small industries are curtailed on account of the shortage and high cost of raw materials and fuel. Diets become increasingly dependent on purchased foods. Nutrition and health may suffer from lack of wild foods and fuel.

Energy for cooking and for rural employment is needed in this stage to generate cash for the many new items that have to be purchased and to replace jobs lost owing to the deterioration of the biomass base. Basic activities such as cooking and fuel collection take up a large amount of women's time, so that labour-saving cooking technologies may be necessary to release women for income-earning activities. As more activities are commercialised and families are less able to support themselves through their own production, there are also more potential opportunities for women to specialise in income-earning production and processing, e.g. in energy-related and resource-based activities such as making building materials food processing (drying, baking, brewing), and in petty trade in these products.

In *stage III* ecological decline is patent and biomass and cooking fuels are very scarce. Agriculture is in retreat. Top soil is depleted, ground cover disappears and there are few crop residues for fodder so that livestock raising becomes less viable. Dung, roots and sweepings are the only fuels available and most households must purchase all or most of the fuel they need. Droughts may become increasingly frequent and populations increasingly dependent on food relief. Nutrition and health are poor. The final resort for entire families is out-migration as "ecological refugees" to cities or relief camps.

Energy for reclaiming wastelands and generating incomes on fragile lands is a priority in this extreme situation. Gradual rehabilitation through progressive planting of grasses, bushes and trees and labour-intensive infrastructure works, e.g. terracing and irrigation, could provide the "energy boost" from outside that these degraded areas need, while also employing people displaced from agriculture.

While this rough outline makes it possible to conceptualise the type of energy intervention that may best respond to the priorities of the poor (and especially of poor women) and the local physical and socio-economic circumstances, in order to translate those priorities into effective action a participatory approach to project design and implementation is essential.

Energy for the poor: A participatory approach to project design and implementation[4]

Attempts to remedy the situation should start from an assessment of existing activities, needs and problems made both by external and national experts and by the people themselves. The assessment should be based on participatory methods – which can include both quantitative surveys and qualitative interviews and group discussions. Implicit here is the idea that needs can be effectively identified and solutions acted on only if the individuals and groups concerned have themselves analysed their problems and found the answers. Action research can help the target populations to understand how their immediate poverty problems relate to broader environmental and social issues and to identify technological and other alternatives for making improvements. This approach usually requires a sensitive outsider able to establish close links with key members of the community and provide continuing support to fledgling women's and peasants' groups.

An organisational framework is necessary for helping the people to analyse their needs and to overcome the many obstacles to effective action. The groups set up for the purpose can include both men and women. However, experience has shown that working with women separately, or taking specific measures to make sure that women are able to voice their concerns, is often necessary to ensure that they benefit. If they do not, the project is likely to fail in its other goals as well.

Projects that start from the preconceived notion that improved stoves or village woodlots are *the* solution to the problems facing women will probably not respond to their most pressing needs. However, renewable energy and forestry projects, where they avail themselves of proven energy sources (such as wind-powered irrigation of vegetable or other "home" gardens or hydro-powered grain grinding) and more efficient end-use devices (such as fish smokers and food processing stoves), can help women to meet their priorities of increased income and family welfare while at the same time economising on woodfuels or complying with other energy policy objectives.

Another essential step in this approach is to facilitate access to land, technical expertise and credit. Secure legal land rights are fundamental for any forest- or agriculture-based activity. The lack of access to appropriate technical expertise is a major obstacle for women in improving their productivity. Special mechanisms such as group credit, as well as group access to marketing and raw materials, are also needed to enable the poor to undertake new activities.

Let us now see how this approach can be applied in trying to achieve two common energy policy goals – managing energy demand and increasing energy supply – by combining them with rural development objectives.

Managing energy demand and increasing family welfare through improved household fuel planning and cooking efficiency[5]

Managing energy demand obviously implies dealing with the needs and preferences of energy consumers, and in households these are primarily women. Many attempts to popularise new, more efficient stoves have foundered on the discovery that women cooks are not chiefly concerned about saving fuel. Even where fuel is commercialised, as in urban areas, fuel savings are often considered less important than time saving and other user conveniences. Partly for this reason, the results of efforts to save fuel have often been disappointing (Manibog, 1984; Foley and Moss, 1983).

Moreover, given the decline in fuel use and living standards that many poor families are experiencing as a result of higher costs and growing scarcity, it would hardly be surprising if more efficient stoves and fuels were being used not to save fuel but rather to restore family welfare (e.g. use of heating, more cooking) to pre-scarcity levels. This is why it may be unrealistic to launch programmes to improve cooking efficiency with the sole aim of saving fuel. It is also why nutrition and health planners and extension services, as well as energy policy-makers, should be involved in planning and carrying out such programmes. If they are to be successful, such programmes must be implemented by interdisciplinary teams and based on a systematic assessment of needs.[6] The characteristics valued by women in cooking should be provide for local variations in cooking habits, fuels, seasonal and alternative uses of the stove, and so on. The nutritional and health aspects of women's cooking are also extremely important.

Stoves should be properly designed and tested by both technicians and cooks to ensure that they *do* deliver promised benefits in fuel saving and other respects. The collaboration of stove technicians with consumers' (women's) groups can be an effective way of choosing stoves to satisfy individual needs, as was confirmed in a recent project in Ethiopia (ILO, 1986b). Adequate production capacity and marketing networks must also be ensured.

The urban areas should receive special attention, partly because of the often desperate need of the urban poor for cooking fuel and partly because these areas tend to siphon off rural woodfuel resources. A variety of alternative fuels, stoves and other means of achieving fuel economies should be considered. Improved stoves are in fact more likely to catch on in urban or highly commercialised rural areas, where the cash costs of inefficient fuel use are high. Co-ordinated approaches to cooking practices, pot materials and types, diet, and fuel preparation and storage may be as effective in saving fuel as are improved stoves, and merit more attention.

Stoves projects in rural areas, however, come up against great obstacles. The low cash cost of biomass fuels in most areas tends to make the purchase of artisan-made stoves financially unattractive despite the potential saving of women's time in fuel collection. On the other hand the fuel efficiency and ease of construction of low-cost owner-built "mud" stoves have been increasingly questioned: smokelessness, prestige and other factors may be more important than fuel savings for some rural users.[7] Improved stoves certainly have a part to play in reforestation programmes and in the general efforts of extension agents to improve nutrition and health.

Biogas technology has not lived up to its expected potential for providing rural cooking fuel either; successful household or community projects are rare. However, biogas experiments may have failed because it was mainly men, without much interest in household energy, who organised them and set the objectives. Pilot projects for biogas plants run by women, for example a cattle-owning group, might therefore be tried.

While some changes in food use patterns in response to fuel scarcities have been identified (reducing the number of meals, cooking less, eating processed foods), the links between fuel savings and nutrition need to be investigated more thoroughly in the light of other factors; nutritionists should, at the very least, establish what potential effects such dietary changes may have on nutrition. The apparent inverse ratio between time spent on cooking and that spent on fuel collection also has nutritional implications which should be looked into more closely.

Nutritionists could also help to identify fuel savings that could be made in food preparation. Basic information on the quantities of fuel needed to show how foods can be cooked with less fuel. Other cooking methods and the use of retained heat, or hayboxes, might also be systematically investigated and the findings disseminated by nutritionists and home economists. The availability of processed foods also changes food habits, and their consumption often has a detrimental effect on nutrition. On the other hand, the availability of ready-to-eat "street foods" reduces the fuel demand of many households.

Increasing energy supply and promoting agricultural productivity: Forests and land for food, fuel and fodder

Like demand management, energy supply development must take into account users' priorities, especially those arising from the shortfalls in food and income that households have experienced as a result of the general rural biomass crisis and the decline of agricultural productivity. Fuelwood is the lowest-value wood product of forests and therefore is unlikely to be the most important product for rural households (unless profitable external markets such as cities are nearby and natural forest resources are depleted to the extent that cash cropping of trees for sale becomes worth while). Yet it is also clear that it is far beyond the capacity of forestry services to plant enough trees to meet future wood and fuel needs. This can be done only by decentralising tree planting and therefore fuel production.

It has been explained above why, with the biomass crisis, rural women urgently need alternative sources of food and income. These needs could be met by combining tree and other biomass planting.[8] Increasing food production was the top priority identified in Ghana and Mozambique, yet fuel is scarcer than food in some areas of Kenya, fodder for livestock is an important need in much of Asia, and in the relatively monetised rural economy of Peru earning cash income from natural resources is essential. The nature of the agrosilvicultural farming system that ought to be introduced will depend partly on households' and women's access to land: agroforestry can be practised on small farms, and food/fodder/fuel production can be combined in home gardens, on wastelands or on communal holdings. The legal and sociological obstacles to women gaining control over land deserve special attention.

Where the priority needs are to stabilise soil production, to generate income and to grow other products, the solution may be to *combine trees and field crops* on women's own holdings or on family land. This approach need not be limited to tree planting but can include bushes and other plants; or there may simply be a need for better management of fallow and shifting cultivation, e.g. by leaving some of the more valuable species when clearing. Scattered farm trees, improved fallows, alley cropping, mulching, buffer strips, terracing, windbreaks, live fencing and "interstitial" planting between improve agriculture and also produce wood, fodder, fruits and so on, either for immediate sale, for further processing or for home consumption.

Even in areas where land is scarce or where women do not control extensive farmland, the land immediately surrounding the homestead is often used by women to grow vegetables and other foods for family consumption. The productivity of these *home gardens* can often be greatly increased by combining tree and bush cultivation with agriculture. Like more extensive agroforestry, home gardens can provide food, fodder and fuel (not to mention cash income); and the time previously spent on walking to gather such resources can be put into cultivating the gardens. The diversity of crops and products in these agroforestry systems can also help to avert the problem of seasonality and timing of production, so that some food crops are available when supplies are otherwise low.

Near cities or industrial markets, other potential income-generating activities lie in the production on *wood lots or orchards* of fuelwood, charcoal, poles, fruit or other items for sale or further processing. Women already have experience with food and raw material processing, charcoal making and wood preparation, and with trade and commerce in these products. These wood lots and orchards could also serve to provide wood and other products for home consumption.

The above proposals for making good the existing food and income shortfalls are all based on the assumption that women can add trees to land they already control. However, many women head, or belong to, families that have no land, especially in certain parts of Asia and Latin America. Yet these women have an even more urgent need for biomass products and income. Enormous expanses of uncultivated *wastelands* (overgrazed pasture lands, communal property, roadside ditches, etc.) exist on every continent. Some governments have already launched experimental schemes to give the poor access to such land. While the most notable example is India, such schemes are not limited to Asia. In Lesotho, for instance, it has been proposed that deep gullies caused by erosion should be reclaimed by leasing them to co-operatives of the landless in return for a labour commitment to maintain the reclamation infrastructures.[9] The potential for land regeneration in the Sahelian region, for example as part of labour-intensive public works, is obvious.

Because of their need to secure quick returns of food and income, women and the poor in general will have to start gradually with quick-growing grasses, food crops and medicinal herbs, for example, before they can invest in bushes and trees that take longer to grow. This sequence could also help to restore degraded lands. External assistance will often be required to enable poor groups or individuals to secure rights to these lands. Even where property rights as such are not acquired, right of access to what is grown on the land would give women a guarantee that the fruits of their labour are not lost to others. While individual control over land may be a out activities jointly. Organisations of women and the rural poor will also require external assistance in obtaining the expertise, credit and marketing facilities they need.

Using energy to improve women's productivity and incomes

In all of their income-generating activities women are handicapped by their restricted access to land, raw materials, technology, skills, credit, extension services and so on. Transport and marketing (apart from what they can carry on their heads) are often major problems because of the constraints on their mobility and social contacts and because they seldom own means of transport, whether donkeys or trucks. To produce sound results any income-generating project must solve the problem of access to these essential inputs.

Energy is only one of the inputs needed for successful productive activities but it is crucial in determining the labour requirements and productivity of any small industry. So far, however, direct energy use in women's productive activities has received little attention.

More efficient energy supplies could improve the productivity of women's small-scale industrial work, especially work that is fuel-intensive such as food processing and ceramics. The scarcity of both fuel for process heat and labour for cutting, grinding, stirring, etc., often puts limitations on women's non-agricultural activities. Fish smoking ovens, rice parboiling units, oil purifiers, palm fruit sterilisers, crop driers and roasting units are examples of fuel-saving equipment that could increase the profitability of women's post-harvest and food processing activities.[10] They should be viewed, however, as part of a package of inputs needed for income generation, together with raw materials, credit and marketing.

Perhaps the most important constraint that women face, however, is their lack of time: this is the "real energy crisis" for them (Tinker, n.d.). The availability of alternative energy sources could release women from repetitive, unproductive household tasks and thus give them more time for productive work. The improved household fuel supplies and technologies discussed above are one such strategy. Time- and labour-saving technologies are crucial for improving women's productivity, income and health, but, ironically, in order to purchase such technologies women must first earn income or have access to credit.

The differentiation made between "household" and "productive" work and the low value placed on women's work generally are obstacles to improving the productivity of their household work. Although time-use studies have highlighted the long working hours of women, the opportunity cost of women's time is usually considered to be zero. Alternative methods of evaluating women's time are needed. One possible approach is cost-benefit analysis to quantify the cost of fetching and preparing woodfuel (as well as wage rates, in order to arrive at a realistic idea of women's economic contribution. Such assessments could then be compared with similar analyses of the cost of providing subsidies for alternative fuels and/or credit systems for the purchase of alternative stoves.

Conclusion

Rural women are shouldering the major burden of environmental degradation and economic distress in many developing countries: working longer hours to produce enough food and income to support their families while having at the same time to collect fuel and water, with less family labour available because of male migration. In times of crisis, such as drought and famine, women's contribution to family income and survival is even more crucial. Yet the access of many women to resources, including energy, is actually declining, while their workload is increasing. Fuel for cooking and heating, wild foods, fodder, and biomass raw materials (including energy) for small industry are becoming increasingly scarce in many regions and the shortages, which can have serious repercussions on family nutrition and health as well as on incomes, are likely to get worse.

Neither energy policies nor rural development policies have so far come to grips with the links between rural women's work, energy and the environment. Poor women have often failed to see the links themselves because of their overriding, immediate preoccupations with food and income. Energy can nevertheless serve as an extremely useful starting-point for meeting women's priorities through participatory projects. Grass-roots organisations have a vital role to play in identifying group needs, in obtaining access for the poor to such essential inputs as land, credit and technical expertise and in overcoming other obstacles.

It is possible both to manage energy demand and to increase family welfare through improved household fuel planning and cooking efficiency. Woodfuel supplies can be increased and agricultural productivity promoted through agroforestry and other more efficient ways of using land to produce food, fuel and fodder. Decentralised energy supplies can improve the productivity of women's income-generating and household activities. And by combining rural development and energy goals in a participatory approach, it is possible to meet both objectives more effectively.

Notes

[1] Examples cited in this article are mainly drawn from the following ILO country studies: E. Alcántara et al.: *Crisis de energía rural y trabajo femenino en tres áreas ecológicas del Perú* (Geneva, ILO, 1986; mimeographed World Employment Programme research working paper;

and household survival (Geneva, ILO, 1986; mimeographed World Employment Programme research working paper; restricted); S. Dasgupta and A. K. Maiti: *The rural energy crisis, poverty and women's roles in five Indian villages* (Geneva, ILO, 1986); P. García et al.: *Trabajo femenino rural, combustible de uso doméstico y nutrición familiar* (Geneva, ILO, 1986); Indonesian Rural Women's Work and Energy Project Team: *Rural women and social structures in change: A case study of women's work and energy in West Java, Indonesia* (Geneva, ILO, 1986; mimeographed World Employment Programme research working paper; restricted); F. Sow: *Les femmes et les projets d'énergie au Sénégal: impact sur le travail féminin et le bien-être familial* (Geneva, ILO, 1986).

[2] Plastic wastes reported to be eating away metal roofs and chat twigs said to transmit tuberculosis.

[3] I am indebted to Ben Wisner for many of the ideas, and indeed for key phrases, in this section (Wisner, 1986).

[4] For a comprehensive discussion of participatory approaches see in particular P. Oakley and D. Marsden: *Approaches to participation in rural development* (Geneva, ILO, 1984) and ILO: *Report of a Regional Workshop on Women's Organisation and Participation in Development*, Madhurai (India), 18-22 November 1985 (Geneva, forthcoming).

[5] This section and the following one are based on the findings and conclusions of a Preparatory Meeting on Energy and Rural Women's Work held in Geneva in October 1985 (ILO, 1986a).

[6] Some useful guides to stove project assessment and monitoring have recently been published. See, for example, Joseph et al., 1985, and Intermediate Technology Consultants, 1985.

[7] In one of the villages studied in West Java improved stoves were introduced under a rural development programme to raise the inhabitants' consciousness of women's work and the technology they use in the household, to stimulate interest and experimentation in technologies with forward and backward linkages to rural industry and marketing, and to provide a fledgling co-operative with the challenge of managing a technology and small industry development problem, in addition to saving fuel (Poerbo et al., 1985).

[8] The following section is based partly on French, 1986.

[9] Personal communication to the author from Ben Wisner.

[10] A useful manual on these and other ways of easing rural women's work is ILO, 1984.

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PART II

Summary and Conclusions

This is the third in a series of World Bank papers dealing with renewable energy resources and issues in developing countries. /1 It is a desk study of some of the principal technical and institutional barriers to more rapid utilization of renewable energy resources. Its focus is on the research required to develop renewable energy resources in the developing countries and on the need to strengthen the developing countries' own technological capabilities for using renewable energy. The purpose of the study is to specifically identify and call attention to these needs and to suggest action, including research and technical assistance programs, that should be undertaken by the international community to help meet them.

The paper discusses the current state of the art in the production and use of biomass for primary energy and the potential for biomass development through research. It also reviews a wide array of existing technologies (many of them in use for centuries) for converting renewable primary energy resources, including biomass, directly into heat, mechanical and electrical energy, and into convenient fuel forms (gases and liquids).

Biomass is the principal primary energy resource for many developing countries today; in some countries, up to 90 percent of energy consumption comes from biomass. The paper concludes that present research efforts to improve biomass production are inadequate to even begin to realize the enormous potential of this resource for the longer term. Impending or existing shortages

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/1 See "Alcohol Production From Biomass in The Developing Countries." (World Bank, September 1980) and "Renewable Energy Resources in the Developing Countries," (World Bank, November 1980).

of biomass in many developing countries, exacerbated by increasing prices of fossil substitutes, make it all the more imperative to enhance and more sharply focus the research effort in this area.

In assessing the capability of the developing countries to respond to opportunities for expanded use of renewable energy resources, the paper points out that the diversity of the resources and the wide range of conversion technologies present the developing countries with a complex set of choices. Certainly, LDC governments should be sensitive to the potential of renewables and should be willing to establish an appropriate policy framework to stimulate the use of such resources. But beyond this, many developing countries lack the capability to accurately assess national energy needs and resources of all types, to choose appropriate technologies, to adapt technologies to local conditions, and to establish effective institutions for their manufacture and distribution. External assistance should be directed toward the strengthening of national capabilities to optimize research, development, and use of renewable energies in the context of an overall energy strategy. To help determine the targets for international support, the paper recommends a country-by-country assessment program that would identify the areas in which national technical capabilities most need to be strengthened.

By supporting technological research and assessment, new international programs can help promote innovation, adaptation, and the diffusion of renewable energy technologies. Because of marked differences between biomass production, on the one hand, and technologies for the use of direct solar, wind, small hydro, and biomass, on the other hand, different types of programs will be needed in these areas.

In the case of biomass production, it is recommended that a mechanism be developed for channeling funds into an internationally coordinated research program aimed at filling the "gaps" in the present research effort in areas of special interest to developing countries. This program would help provide the additional resources, stimulus, and coordination necessary to expand ongoing research so as to mount a concerted effort to improve technologies for producing biomass for energy from familiar and novel species of trees and energy crops. The potential for energy-oriented biomass production on nonagricultural land under difficult ecological conditions would be investigated by means of both traditional and advanced methods of research.

In the case of the other technologies, much research to improve the state of the art is already being done in the developed and more advanced developing countries in response to commercial and other incentives. The recommended international program would be directed toward assisting the developing countries to assess and adapt new technologies for use in national programs of research, development, and manufacture. The aim of the international program would be to develop reliable data on the performance of renewable energy technologies and equipment, to evaluate experience in different countries with the adaptation and diffusion of such technology, to make global assessments of future technological developments and their implications for developing countries, and to awaken interest in "dormant" technologies that may today have high potential.

Although for analytical and presentational purposes, it has been useful to distinguish between the programs aimed at improving local capabilities and those aimed at advancing technology per se, it must be emphasized that the two would be inextricably linked in practice. The strengthening of national scientific and technical capabilities can be expected to contribute to technological progress on many levels. Conversely, the recommended international programs of research and assessment can be expected to help raise national capabilities significantly by providing support for research in national institutions and by improving the quantity and quality of the information available to national programs.

The suggested institutional arrangements for carrying out these programs would maximize the role of national and regional institutions and would require only small central staffs. The arrangements would be compatible with a variety of possible mechanisms for ensuring adequate funding and maintaining accountability, but it is important that these mechanisms be such as to permit the programs to be managed in a wholly professional manner. Since the recommended programs for the generation and assessment of technological information would involve a major effort in fields in which there is little precedent for effective international action, they should begin with pilot programs for selected technologies.

MOBILIZING RENEWABLE ENERGY TECHNOLOGY IN DEVELOPING COUNTRIES: STRENGTHENING LOCAL CAPABILITIES AND RESEARCH

1. INTRODUCTION

Background

The increased price of fossil fuels and the threat of deforestation present the developing countries with a major challenge. An important element in their response will be the mobilization of technology for the use of renewable energy resources. 2/ Renewable energy will do more than save scarce foreign exchange by replacing increasingly expensive fuel imports. Not only will it continue to be the major source of cooking fuel for the poorer majority, but it will also provide energy for development in forms that are less costly, more efficient, and more appropriate than expensive fuel imports.

In seeking to increase their use of renewable energy, the developing countries face three obstacles. First, they face a rapidly evolving technology since renewable energy technology was neglected in favor of fossil fuel technologies during the years that cheap petroleum was available. Second, they must choose, for a broad range of applications, from technologies that vary in sophistication from photovoltaic cells to clay stoves and village fuelwood

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2/ Renewable energy is used in this discussion to mean an energy form, the supply of which is partly or wholly regenerated in the course of the annual solar cycle. The specific forms of renewable energy discussed are solar and wind energy, small hydropower, and fuels of vegetable origin. Large-scale hydroelectric power is not considered because it involves conventional technology with a well-established role in electric power systems. Wave, ocean thermal, and tidal power are also not discussed. The line between renewable energy technology and conservation technologies has been somewhat arbitrarily drawn: specifically, wood stoves are considered, but passive solar architecture is excluded.

lots. Third, many of the rapidly changing technologies that they must become acquainted with and match to their needs were developed to meet needs other than their own. These obstacles can be overcome if appropriate and adequately funded research and development efforts are supported by the international community.

Where will the technological advance required for the practical applications of renewable energy in developing countries originate? Much of the impetus will stem from the efforts of public or private companies in industrialized countries. These companies are responding to the new energy economics by using modern materials and established engineering principles to improve neglected technologies, as well as to develop new technologies.

To speed this advance, several industrialized countries (and a few developing ones) have encouraged research, development, demonstration, and commercialization of renewable energy technologies and applications. These activities have taken place in both government institutes and in the productive sector. 3/ They range from the applications of well-known principles of science and engineering to explorations at the frontiers of knowledge. The policies and programs involved are concerned mainly with sophisticated technologies needed by the industrialized countries. Once these technologies are proven, they will become available to the developing countries through normal commercial channels. Advances in such fields as the hydrogen economy, photosynthesis, and fusion could have major long-term effects on energy use throughout the world.

3/ The productive sector refers to that part of the economy, whether privately or publicly owned, which produces goods and services.

Experience shows, however, that technology imported from industrialized countries seldom matches the needs of developing countries. It requires major changes in scale and extensive adaptation to suit local conditions. This is true even for the modern sector of developing economies. Many technologies of great potential use in the developing countries have only been minimally tested in these countries. In any event, such technology is frequently beyond the resources of poor people in developing countries. Their special needs are unlikely to attract investment in innovative technology from the private sector.

For these reasons, many of the technologies needed in developing countries will be developed or adapted locally or will be transferred from other developing countries. The widespread application of these technologies can be brought about in developing countries by two significant steps: by advancing or adapting these technologies; and by building within the developing countries the capability to undertake these advances and apply them effectively. This task requires competence in engineering and in both the natural and social sciences. It requires the ability to assess needs and resources. And it requires the skill to choose, adapt, and create the necessary technologies, as well as the ability to establish appropriate institutions for the manufacture, commercialization, and distribution of these technologies.

The Report

The World Bank has recognized the need of its member countries to meet the challenge of developing their renewable energy resources. It constituted a Task Force on Renewable Energy in December 1979 to consider the Bank's role in the development of renewable energy and to recommend an action program for Bank lending and activities in the years immediately ahead. The findings of the task force are reflected in the Bank's report Energy in the Developing Countries (August 1980) and are presented in detail in the paper Renewable Energy Resources in the Developing Countries (November 1980). These documents reflect the Bank's commitment to support the development of renewable energy both by expanding its investment lending, particularly for fuelwood and alcohol production, and by providing greater technical and financial assistance for the strengthening of developing country institutions.

In Energy in the Developing Countries it is pointed out that "attention needs to be given to strengthening national research programs and to the possibilities of organizing international programs of research on specific renewable energy technologies." The Bank has been particularly concerned with research and development requirements for increasing the utilization of renewable resources in developing countries and with the scientific and technical capabilities of developing countries for using renewable energy. During a special study of these subjects undertaken in connection with the Task Force exercise, consultants prepared reports on renewable energy programs and capabilities in a number of developing countries, on bilateral assistance for renewable energy development, and on biomass production research needs; additional analyses of renewable resources and technologies were prepared by Bank staff and consultants. To review and reinforce its work in this area, the Bank also convened in November 1980 the Ad Hoc Advisory Committee on Research and Technological Capacity for the Use of Renewable Energy, consisting of twelve experts from developing and developed countries.

The discussion of renewable energy resources in this report is divided into three sections. It begins with an assessment of needs for building a local capability for mobilizing renewable energy technology in developing countries. This theme is treated first because the basic issue for developing nations is not so much promoting the development of particular items of technological hardware, but rather developing the capability to identify problems and match solutions to them. After a brief overview, the section reviews the present state of national capability and the scope of existing aid programs. It concludes with several recommendations. The following section addresses the need for research into and assessment of an extensive list of technologies relevant to the needs of developing countries, beginning with agricultural technologies for biomass production and their applications, and then technologies for generating heat, mechanical, and electrical energy. On the basis of this review, new international programs are proposed. The final section summarizes the report's recommendations and possible institutional arrangements for implementing them.

2. BUILDING CAPACITY IN DEVELOPING COUNTRIES FOR MOBILIZING RENEWABLE ENERGY TECHNOLOGY

Because many techniques at various levels of sophistication can be used for expanding renewable energy resources, some degree of local technological capacity in renewable energy is within the reach of every developing country. Some countries are planning and implementing major integrated multi-sectoral programs for the exploitation of renewable energy resources. They aspire to leadership in areas that require a substantial industrial and technological base, such as the production of ethanol fuel from biomass. Other countries may find it more appropriate to concentrate on adapting and diffusing simpler, less expensive technologies, such as cooking stoves and biogas.

The aforementioned report on "Renewable Energy Resources in the Developing Countries " stresses the two important roles of national research programs: "In the first place, [they are] a vital part of the technology transfer/absorption mechanism in that they enable developing country scientists and technologists to acquire direct working experience with the new technologies. And, second, they enable the developing countries to acquire the technical ability to adapt imported technologies to the local environment and to improve on traditional local technologies."

The full range of requirements for mobilizing renewable energy technology in developing countries is very broad because mobilization involves many interrelated activities: resources have to be surveyed, needs have to be assessed, existing technology has to be reviewed and matched to national resources and needs, and research must be undertaken to develop and/or adapt technologies. The technologies so developed must be demonstrated, and steps taken to assure their local manufacture, commercialization, and diffusion. Policies also have to be established concerning the economic and sociocultural elements affecting use of renewable energy resources, and this includes establishing incentives for their use. Furthermore, the consideration of renewable energy must be integrated into a broad energy policy covering sectors such as agriculture, industry, urban development, and transport.

This type of comprehensive approach to technological development should stimulate institutions ranging from those of the scientific and technological infrastructure--universities, government laboratories, extension services, and the like--to the engineering groups of operating ministries or of private or public sector manufacturing firms, and consulting and engineering organizations. Also involved will be nongovernmental organizations active in community development, resource survey groups, analysis divisions of energy or planning ministries, and private individuals. A proper balance will have to be achieved between efforts to stimulate technological innovation and adaptation and efforts to diffuse technology and encourage its use.

The effective mobilization of renewable energy technology depends on cooperation and synergy among these organizations and individuals. The precise form of this cooperation will depend on a specific country's objectives; on its social and cultural traditions; on its finances, basic materials, and human resources; on the level of its overall development; and on the technologies it needs to use. Local cadres in China, for example, have taken major responsibility for the design and implementation of projects for biogas, small hydropower installations, and village fuelwood. National and provincial organizations are responsible for advanced training, research, and the planning and coordination of the technological development involved. In Guatemala, India, and Sri Lanka, informal voluntary organizations with an intimate understanding of local problems have made important contributions to biogas projects and to the improvement of cooking stoves. Brazil, on the other hand, has a national program on fuel ethanol, which is centrally managed by the federal Ministry of Industry, although most investment is undertaken by private firms. Participants in the program include the national petroleum monopoly, several national laboratories, private research centers, and a large number of manufacturing organizations.

The worldwide response to the new energy era is at an early stage. Insofar as renewable energy is concerned, the adequacy of this response in developing countries will depend, in the first instance, on the creation of sufficient political awareness and commitment. Policymakers must therefore be provided with adequate information on renewable energy needs and resources in the context of overall energy planning and policy advice. To date, the development of renewable energy has often been neglected in the formulation of overall energy policy. The integration of technological capacity with policy making in the renewable energy field, and of renewable energy with overall energy problems, is an objective that has proved as elusive as it is desirable. It must nevertheless be pursued by developing as well as developed countries.

Present State of National Capability

Almost every developing country is attempting to improve its use of renewable energy resources. These activities range from major investments to a few uncoordinated demonstrations. A preliminary review of nineteen countries indicates that their capabilities for mobilizing renewable energy technology stand at three general levels:

At the highest level are countries with a full range of institutions, technical skills, expertise for social analysis, and policy commitment for renewable energy; next, we find countries with a relatively recent policy commitment but only a limited capability, or conversely some capability but no policy commitment; the third level is characterized by countries with a minimal policy commitment and a low level of capability, activities are limited to a few projects, both technical skills and the mechanism for the diffusion of renewable energy technology are limited, and there is little coordination among the few institutions or individuals showing initiative in this area.

Among the countries at the first level, the policy commitment to mobilize renewable energy technology is generally high. There is a strong, or a rapidly emerging, scientific and technological community, supported by adequate facilities. These countries have a substantial manufacturing base and there exists a degree of synergy among the organizations concerned with renewable energy technology.

One of these countries has effectively diffused biogas, small hydropower, and village fuelwood systems throughout its rural areas. It has done so as part of an overall development strategy that emphasizes building local self-reliance, technological infrastructure, and the capability for decisionmaking and innovation. Another has concentrated on the development of alcohol fuels, an area in which it is a world leader, and it also has capabilities and programs in other areas. Two others pursue research and diffusion programs in almost all areas of renewable energy. Another employs policies that encourage renewable energy applications. It has established a large number of research, manufacturing, and training institutions dealing with renewable energy technology. Senior personnel are limited in number, but the government has introduced an aggressive program to encourage skilled emigres to return. Still another country, though not as advanced as others in this category in terms of manpower and infrastructure, has a framework for research, manpower training, and diffusion of technology.

Countries at the second level of capability have concentrated on relatively simple technologies. The commitment of their governments to the use of renewable energy resources is leading to the creation of an infrastructure, of human resources, and of appropriate policy and institutional mechanisms. Most of these countries lack technical personnel and rely on expatriates for their senior staff. In one country the need to develop strong organizational and project management skills in public sector organizations was identified as a critical condition for further progress. Some countries have a large number of entities working on renewable energy, and are in the process of formulating policies to establish linkages among them. Others are capable of research and manufacturing, but not of performing surveys or making energy assessments. Others have a concrete plan, but lack the financial and technical resources to implement it. Accordingly, mechanisms for commercialization and diffusion have not yet fully evolved in these countries. They have achieved a reasonable degree of informal cooperation at the working level, but lack a mechanism to insure that renewable energy projects are continuous or that they are consistent with broad national objectives.

Countries at the third level lack an institutional framework for formulating policies and programs for the development and diffusion of renewable energy technologies. Activities are limited to a few uncoordinated projects. A few countries in this group have virtually no indigenous capacity for either research or diffusion. The few active projects that are being undertaken in the countries are managed and executed by expatriates. There is no evidence of a coordinated attempt to develop and exploit renewable energy resources. Of this group, two oil-exporting countries have given low priority to renewable energy resources and have not tapped their skilled manpower potential. As a result, even the limited activities pursued at universities and other research centers are isolated and fragmented. In another oil-exporting country, skilled scientific researchers are working on a few projects and have well-equipped facilities, but there is no apparent interest in diffusion or commercialization of renewable energy technology or equipment. In two other countries, the research effort is neither coordinated nor linked to the productive sector for diffusion and commercialization. Both these countries have recently begun to develop an energy plan.

In certain parts of the world, efforts at regional cooperation in the field of renewable energy have begun. Such cooperation would allow countries to pool their limited financial or technological resources. In West Africa, for example, six nations (Senegal, Mali, Niger, Upper Volta, Ivory Coast, and Mauritania) have agreed to establish a regional renewable energy institute in Bamako (Mali), linked to affiliated centers in member countries. A number of Pan-Arab organizations, including the Organization of Arab Petroleum Exporting Countries (OAPEC), have expressed interest in cooperation among Arab countries in renewable energy research.

Assistance Programs

An increasing amount of financial and technical assistance for the development of renewable energy resources has been made available to developing countries in recent years under bilateral and multilateral programs. A survey of eight bilateral programs indicates a mounting interest in renewable energy assistance from this source, although the programs studied varied widely with respect to organization, funding, and program development. 4/ The World Bank has been increasing its lending for fuelwood projects and, as already indicated, intends in the future to expand substantially its lending for the development of this and other renewable energy sources. The regional development banks have also been concerned about increasing their support for renewable energy. Almost all of the major specialized agencies in the United Nations system now have programs for renewable energy, and the regional commissions are also paying increasing attention to this area.

Most of the developing countries are receiving assistance under one or more of these programs, which have undoubtedly contributed to the development of renewable energy awareness and technology in a number of important ways. In general, however, existing assistance programs do not appear to have fully recognized the critical importance of building local capability for renewable energy development. Not much attention has been given so far to the analysis of needs, the development of local capability to undertake research on the technological, social, and economic impact of renewable energy resources, or to planning for the widespread utilization of these technologies. The creation of local institutions and mechanisms for the marketing and commercialization of renewable energy technologies has also been neglected. Specific projects have frequently been regarded as ends in themselves rather than as a means for securing, through extensive testing, evaluation, and adaptation, the widespread use of the technologies within the country.

4/ T. Bartlem and R. T. Hoffman, "Policies and Programs for Renewable Energy Assistance in Eight Development Agencies: Summary and Critical Evaluation" (World Bank mimeo report, January 1980; available from the Science and Technology Unit). The eight programs are those of United States, United Kingdom, France, the European Economic Community, Germany, Canada, Sweden, and the Netherlands.

Programs of bilateral aid for the development of renewable energy resources are relatively new and still evolving. Most of them have been oriented toward the demonstration of hardware developed in the laboratories and enterprises of the donor country. Some donor countries have attempted to use aid to create export markets in the developing countries for their own solar industries. Most of the research is still done in the home country. The technologies are not designed to suit conditions in the developing country; rather, many project conditions seem to be chosen to display and test the technologies under particularly favorable circumstances. Now that they have gained experience in renewable energy assistance, however, the bilateral agencies seem to recognize increasingly the importance of building local capability.

Many aid agencies are inadequately informed about the activities of other such agencies. They could benefit from a systematic exchange of information, including interagency meetings. Topics involved could be the overall level of efforts of each agency in each country and in each technology, as well as information on project plans and experience. This process should have a threefold impact: the agencies could learn from each other's experiences, avoid duplication of efforts, and agree on priority areas for aid activities. Ideally, incountry coordination is the task of the recipient country and is an element of local capability. The purpose of coordination among donors would be to make this task easier.

Recommendations

The extent to which countries need external assistance in developing their capability for the use of renewable energy resources depends on three factors: commitment, current capability, and national resources and needs. The following recommendations, which have taken into account these factors, first consider the three levels of capability already described, and then address broader needs.

Developing countries of the first group have substantial programs for development of at least a few kinds of renewable energy resources and several have successfully manufactured internationally competitive equipment. Equally important, they have achieved a degree of synergy among different programs and at least the beginnings of coordination with policymakers. Several countries have done this with little or no outside help. In their fields of competence, these countries can relate to the scientific and technological community of the world as full members or even as leaders. They can collaborate with their peers in other countries, define their own needs for expert assistance, and offer assistance to other developing countries less advanced in these fields. In these countries, needs for international cooperation are likely to involve advanced training, the expansion of existing infrastructure, and funds for research, development, engineering, demonstration, and market development. The funds would be channeled both to government institutes and to the private sector, and would include measures to facilitate international collaboration with national researchers. Measures to encourage the transfer to and mastery of imported technology in the private sector may also be needed, as well as measures to facilitate joint ventures and other suitable business arrangements between domestic and foreign firms.

Countries of the second group have recognized the potential importance of renewable energy. They have made a start, in most cases a small one, toward launching a balanced program and policy reasonably consistent with their equally limited overall energy efforts. These countries, in most cases, need external assistance in formulating and executing policies and programs. They also need help in developing a manpower and institutional base. If such assistance were offered, these countries would be expected to respond favorably, as they are in the early stage of building their capability. It is particularly important that investment and demonstration projects in these countries be planned and implemented in such a way as to maximize the building of local capability. Close linkages between research, development, and demonstration programs and the productive sector should also be encouraged.

Awareness of the potential importance of renewable energy technology is very low in the third group of countries. Research, development, and demonstration activities are confined to laboratories, frequently in universities, which are isolated from potential users. In such countries, official interest and support might be best attracted by a dual approach, that is, one that would combine policy studies projecting energy needs and the available resources and technologies with a program aimed at selecting, adapting, and diffusing a particular renewable energy technology to meet some major national need. Such programs can be effective only if they carry through all stages of the innovative process, including the identification of a need, the selection and adaptation of a technology, and commercialization and diffusion, at least on a pilot or, preferably, on a semicommercial scale. If this process were successful, it would be followed by international support for broader technological infrastructure programs in renewable energy that would include appropriate diffusion mechanisms.

Whatever the level of involvement in renewable energy, most developing countries need to conduct a substantial training program. Such a program for renewable energy professionals should include not only training in a professional function but also measures to facilitate career development, for example, international travel and collaboration and sabbaticals abroad. There is also a need for broad multidisciplinary training of energy planners, training in specific technologies, and training of professionals for whom energy is not a primary concern, such as irrigation or transportation specialists. There is a particular need for short courses to inform energy planners who were trained only in conventional technology of developments in, and potentialities for, the use of renewable energy.

An effort should be made at the national level to collect the technical and socioeconomic data needed to formulate national policies on renewable energy. A helpful approach is to establish the pattern of energy demand and supply. Simple models can then be applied to provide different scenarios for judging the overall impact of renewable energy technologies. Patterns of energy use in villages should also be studied.

Bilateral and multilateral development assistance agencies should expand and intensify their efforts to assist in the building of local capabilities. Such efforts should encourage cooperation among scientists and organizations of developing countries whenever appropriate to the task at hand. Indeed, renewable energy provides a particularly fertile ground for technical cooperation because much information of primary interest to one country may derive from the experience of others.

Development assistance agencies should ensure that their projects take into account local capability to assess needs; to evaluate the appropriateness of technologies to address those needs; and to choose, adapt, create, and diffuse suitable technology, including local manufacture when appropriate.

Investment projects for the large-scale application of proven renewable energy technology should be undertaken in such a way as to promote the building of local technological capability and the linking of that capability to the social and economic needs of the country. This development of local capability is a normal aspect of the operational work of the Bank and of many other agencies that assist in development, but it deserves special emphasis in the case of renewable energy technologies. In some cases adaptation of policies and procedures within the aid agencies may be required. This would accommodate the need to plan and to monitor closely the spending of relatively small sums of money for critical capability-building undertakings.

Assistance for the development of technical capability to mobilize renewable energy technology seems particularly suited to grant financing, and there is a critical need to maximize the availability of grant financing to assist the development of this capability. It is unrealistic, however, to expect that sufficient international grant financing will be available to meet all such needs and developing countries should not be reluctant to borrow, if necessary, for the purpose of strengthening their scientific and technological capabilities, in view of the potentially high returns to investments for this purpose.

Aid donors have already begun to reorient their activities in the directions suggested above. They can be further stimulated to provide financial and technical assistance to aid local research, development, demonstration, and diffusion capabilities if priority requirements are expertly identified and reflected in projects suitable for financing. Special efforts should therefore be made to diagnose needs country by country, and to assist in the elaboration of national plans of action for developing technological capability for utilizing renewable energy resources. Practical constraints, such as emphasis on promoting the export of hardware developed in the donor countries and, in some cases, the lack of experienced staff, make it difficult for bilateral agencies to undertake a comprehensive review of the needs of a country and to prepare an action plan.

An international program is therefore needed to help diagnose the priority needs of particular countries for assistance. Such a program would help in the preparation of a plan of action for the development of local capabilities, including proposals for technical assistance. But it would not normally extend to the actual implementation of that plan. This would be the task of existing bilateral or multilateral developmental assistance efforts. The scope of this international program of diagnostic assistance would be thus analogous to the assistance to the development of national capabilities in agricultural research to be rendered by the newly established International Service to National Agricultural Research (ISNAR) of the Consultative Group on International Agricultural Research (CGIAR). 5/ Diagnostic assistance

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5/ ISNAR was established to fill the gap between the work of the international programs funded by the CGIAR and that of national programs of agricultural research. ISNAR will maintain an international staff that will provide technical assistance in the diagnosis of national needs for agricultural research and in the preparation of plans of action and proposals for technical assistance. The implementation of the plans would be funded by bilateral or multilateral sources. The German technical assistance organization (GTZ) has been designated by the CGIAR as executing agency with the task of launching ISNAR, and a staff is now being recruited.

should be available for a wide range of technologies. The program will frequently require close cooperation with existing agencies, such as the Food and Agriculture Organization of the UN (FAO) and the United Nations Industrial Development Organization (UNIDO).

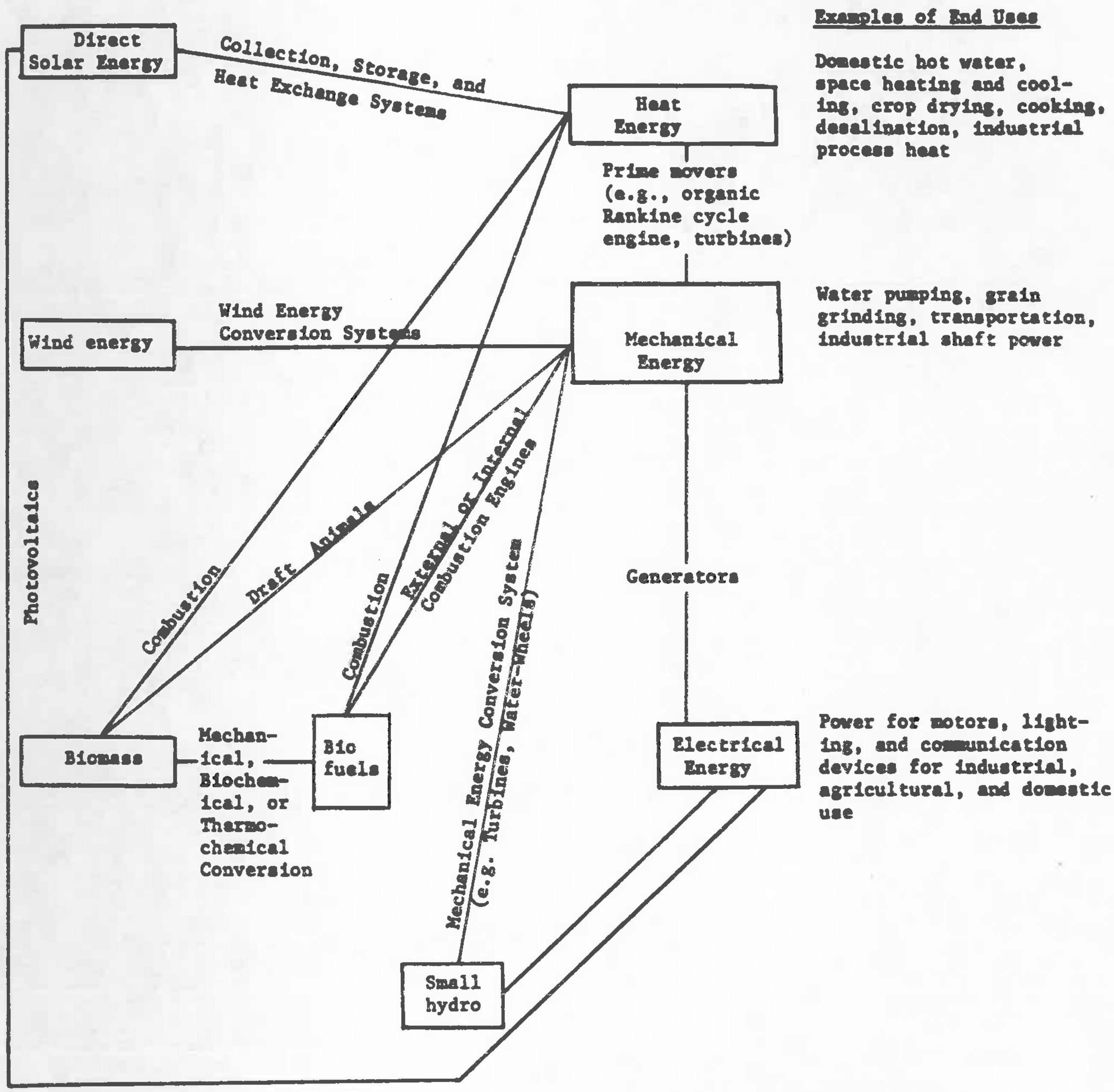
The program, in producing its diagnoses, will thus serve an integrative function that can help donors orient themselves to building capacity in developing nations. It may be useful to convene meetings which would use the results of the diagnoses as a tool to facilitate the coordination of the efforts of bilateral and multilateral donors.

3. RENEWABLE ENERGY TECHNOLOGIES ORIENTED TO THE NEEDS OF DEVELOPING COUNTRIES

Renewable resources can provide energy for a wide variety of applications in the domestic, agricultural, industrial, and transport sectors of developing countries. All these sectors require usable energy in the form of heat energy, mechanical shaft power, or electricity. Figure 1 on page 21 summarizes the main pathways for conversion of renewable energy resources (biomass, solar, wind, and hydro) into these forms of energy. Renewable energy systems may be used individually as "stand-alones" or in hybrid modes with each other, or with fossil-fueled systems. A wind electric conversion system, for example, can be used to produce electricity either alone or in combination with solar-or diesel-powered generators.

Of the energy resources included in Figure 1, biomass merits special consideration because of its present importance and future potential in developing countries. About 70 percent of the population of the developing world--some 2 billion people--today depend on biomass in the form of wood, crop residues, and animal waste to meet their most basic energy need, which is for cooking fuel. Moreover, biomass is a highly versatile energy source. It can serve not only in its traditional role in meeting the major energy requirements of the poor, but it can also meet a wide variety of the needs of the modern sector when converted to suitable solid, liquid, and gaseous fuels. Gasoline substitutes, for example, can be produced from biomass by the fermentation and distillation of plant sugars to produce ethanol, by the gasification and liquefaction of wood to produce methanol, by the pyrolysis of wood and crop residues to produce gas, and by a number of other biochemical

Figure 1: MAJOR RENEWABLE ENERGY RESOURCES AND APPLICATIONS FOR DEVELOPING COUNTRIES



and thermochemical conversion processes. Biomass fuels can be produced through large-scale industrial processes, or on a small scale for local use. On the other hand, biomass resources are unevenly distributed in the developing world. Although some countries are well endowed with biomass, others are poor in biomass because of natural conditions (for example, insufficient rainfall) and/or overuse (for example, deforestation).

The technologies that can convert renewable energy resources into usable forms of energy take the form of industrial processes and equipment. Equipment for some of the more sophisticated of these technologies--photovoltaics, large-scale wind energy conversion systems, wood gasification--can be developed and manufactured only in the industrialized countries, or in some of the more advanced developing countries. Efforts in developed countries are naturally oriented toward their own needs, and special attention is sometimes needed to ensure that technologies suited to developing countries receive attention. Most renewable energy technologies, however, are relatively well known. In most developing countries they can be adapted to local conditions and manufactured by the industrial sector, or, in the case of simple, village-level technologies, they can be adapted and produced by private organizations working closely with artisans and small workshops.

Review of Technologies and Applications

The following review focuses on the technologies and applications that appear most likely, on technical and economic grounds, to be relevant to meeting the energy needs of developing countries in the near-medium term future. The technologies are reviewed here in order to determine the need for innovation and/or adaptation in meeting developing country requirements, the extent to which these needs are being addressed at present through research and development in the developed and the developing countries, and the ways in which the gaps in the present research, development, demonstration, and diffusion effort might best be met through national and international action.

From this review, there emerges a tentative list of requirements for national and international action in research, development, assessment, and evaluation of technologies as they apply to the conditions and needs in developing countries. Technology for biomass production is assessed first, followed by technology for the conversion and use of biomass, and technology for the conversion of direct solar, wind, and small-scale hydro into heat, mechanical, and electrical energy. Specific recommendations are then presented.

Agricultural Technology for Biomass Production

Many developing countries are well endowed with biomass but its production for energy purposes can conflict with agricultural requirements. Thus it is essential to develop biomass production technologies that do not compete with food or cash crops and that will be successful under stress conditions such as arid or saline soils, swamps, and steep slopes. Such technologies should also be labor intensive and adaptable to small farms production.

Biomass energy may be derived from trees, shrubs, oilseeds, grasses, roots, field crops, agricultural residues, or aquatic plants. (See Table 1, page 27A.) Of the technologies for producing biomass, the only ones of near-term technoeconomic interest are the growing of trees for wood fuel and the growing of certain "energy crops," particularly sugarcane (and, to a lesser extent, cassava and sweet sorghum), for fermentation into ethanol. The technology for producing vegetable oil from oil palm and sunflower is also in hand. The technology for using such oil routinely as diesel fuel, however, is still to be fully mastered. Finally, large quantities of straw and other agricultural residues are currently wasted or used inefficiently as fuel. With improvements in harvesting, densification (briquetting, pelletizing, and so on), and conversion technology, more of these materials could be used more efficiently for energy purposes.

There is a pressing need to expand and upgrade energy-oriented biomass production research on both tree-growing and energy crops. There should, in each area, be an expanded effort involving not only applied research of the type now under way but also mission-oriented basic biological research that so far has had little application in this field. Experience confirms that much can be expected in the short term from applied research on familiar biomass sources as represented, for example, by field trials and species selection of fast-growing trees for different ecological conditions. Lesser known species should also be surveyed and investigated. For the longer run, there is much promise in the application to biomass production of the advanced research techniques--e.g. somatic cell culture 6/, genetic engineering and microbiology--that are producing exciting results in other areas of biology. Such research can be pursued at modest cost; it offers an opportunity for research in developing countries, with suitable international support, to play a leading role in the advancement of science, and at the same time to be of direct benefit to the host country.

These lines of research all present to the scientific community the challenge of stimulating communication, collaboration, and cross-comparison

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6/ Somatic cell culture is a technique that allows an entire plant to be grown from a single cell taken from a part of a plant other than the seed.

among all workers concerned with biomass production, whatever their disciplinary origins or institutional affiliations, as well as between these workers and the general agricultural research community.

Trees. Research into tree growing in tropical areas has traditionally been directed toward selection of provenances 7/ suited to industrial wood products and, to a lesser extent, to erosion control and other aspects of soil and watershed management. 8/ In the past few years, some research agencies have shifted their attention to the need for fast-growing trees for fuelwood, fodder, fruit, and pole production, either for forests, village fuelwood lots, or as part of farming systems for smallholders. In general, however, there has been little change in the direction of forestry research, so that it does not reflect the growing concern of developing countries with energy and agriculture-related forestry development. The lag in attention to important new directions in forestry may be attributed in good measure to the inadequate funding of forestry research, a long-standing problem in much of the developing world. Preliminary estimates indicate that the developing countries at present receive only about $10 million a year in aid for forestry research.

The problem of funding forestry research is understandable in the context of its long-term nature and the many pressing claims on developing

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7/ A provenance is a source of planting material--e.g., a particular geographical area.

8/ This section draws on the preliminary results of work being done to identify priorities in developing country forestry research. The results of this work, which is sponsored by the Bank and FAO, in consultation with CGIAR research programs, the International Center for Research on Agroforestry, and various bilateral aid donors, will be presented at an international forestry research meeting in Japan in September 1981.

country resources. Yet, wherever energy-oriented forestry research has been undertaken, it has paid off handsomely. Tree-breeding programs--for example, work in Hawaii on the giant ipil-ipil (Leucaena), in Sweden on the willow (Salix spp), and in Australia on Eucalyptus--have resulted in spectacular increases in yield. Available evidence indicates that breeding programs can be expected to result in growth gains of at least 10 percent for most species, and 15-25 percent gains for some, while applied research in the form of pilot trials of the introduction of exotic species can yield up to twenty times more biomass a hectare than the natural forests they replace. Thus, there seems to be a strong economic case for stepping up forestry research, particularly research into indigenous species suitable for the production of fuelwood and fodder. A recent U.S. National Academy of Sciences study identified some sixty species of trees and shrubs as particularly promising sources of fuelwood in developing countries. 9/ There are no specialized research programs under way at present for most of them.

Those in the forestry profession contend that applied research on growing trees is best suited to national institutions that are highly familiar with local soil, management, environmental, and social conditions. Energy-oriented forestry research is being conducted in several major institutions in developing countries; as well, a substantial number of research centers in the developed countries have programs appropriate for developing countries. There is a clear need to expand and strengthen the work being done in the developing countries, however, and to build closer links between developed and developing country institutions. Forestry research at the international level is poorly coordinated despite the efforts of the Forestry

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9/ National Academy of Sciences, Firewood Crops, (Washington, D.C., 1980).

Division of the Food and Agricultural Organization, which serves as a unifying force throughout the world forestry profession, of the Commonwealth Forestry Council, which is coordinating tests of promising species and provenances, and of the International Union of Forestry Research Organizations (IUFRO), which links research institutions throughout the world but whose programs have been of more benefit to developed than to developing countries.

The forestry research community also needs to strengthen its links with those doing research on other approaches to the biomass energy problem. New approaches to the growing of trees--such as short harvest times and close spacing--are blurring the lines between the discipline of forestry and the study of other forms of biomass, such as shrubs and grasses. An important objective of biomass research is to evaluate according to common criteria all forms of biomass suited to a particular ecological condition. This type of evaluation will enable farmers and competent local authorities to select the system best suited to their needs.

Institutions whose primary mission is in other fields should also recognize the priority of research on tree growing. Research on the use of the leaves of leguminous trees, 10/ of which Leucaena is an example, as a source of fodder and fertilizer in small farm systems would seem to be a high priority for national agricultural research laboratories, and for the international agricultural research centers funded by CGIAR. Basic research on the mechanisms and the ecology of biological nitrogen fixation is being carried on in various agricultural research institutions and universities. Such programs should be extended to include biomass production species, both leguminous and

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10/ Leguminous trees, like other legumes, have nodules on their roots that harbor symbiotic bacteria that fix nitrogen from the air. They are therefore net contributors of nitrogen to the soil.

Table 1: PROMISING ENERGY CROPS OTHER THAN FUELWOOD TREES

	Use	Species	Advantages	Research Needs
Crops producing readily fermentable carbohydrates				
Sugar crops with residual fuel	Ferment into ethanol using residual fuel fpr processing energy	Sugarcane (*Saccharum officinarum*)	Well-known, thoroughly researched production technology; tolerant of poor soils; relatively efficient converter of solar energy; sugar production and fermentation self-sufficient for fuel.	Collect genetic material from China-Assam-Burma Triangle; breed and test varieties and establish cultivation regime for maximum biomass;establish centralized service for recording, processing and disseminating varietal data; select or develop machinery and system to harvest total biomass.
		Sweet Sorghum (*Sorghum vulgare*)	Efficient converter of solar energy; shorter growing season than cane.	Carry out field trials in areas in which sugarcane cultivation is difficult because of cold winter or prolonged dry season. Collect germplasm.
Starch crops with residual fuel		Sago Palm (*Metroxylon spp.*)	Tolerates saline swamps; high yields.	Define agronomic requirements; breed for earlier maturity and higher starch content; try to harvest earlier; use more incident light in early years.
Starch crops with little residual fuel	Ferment into ethanol: external energy source required	Cassava (*Manihot utilissima*)	Widespread crop under subsistence conditions on poor soils; drought tolerant; self-storing underground.	Increase yields under nonsubsistence regime; develop systems for management under large-scale cultivation and for inter-cropping with legumes to maintain soil fertility.
		Buffalo Gourd (*Cucurbita foetidissima*)	Combination oilseed and starchy root; yield apparently very high; native of arid lands; vine is ruminant feed.	Test against possible competitors in a wide range of ecological environments; check evapotranspiration requirements.
		Carob (*Ceratonia siliqua*)	Grows in Mediterranean climate on rocky soil with no other use; agronomic requirements well documented.	Test under similar conditions in other regions.
		Tamarind (*Tamarindus indica*)	Drought resistant; grows on poor rocky soil.	Collect germplasm in Sub-Sahelian Africa; test best Indian varieties under similar conditions elsewhere.
		Tania (*Xanthosoma spp.*), Taro (*Colocasia esculenta*)	Tolerates swampy conditions.	
Cellulosic and ligno-cellulosic (woody) plants	Direct combustion (e.g., cooking fuel, woodburning power plants); digestion into biogas; conversion to methanol/ ethanol	Straw	Available in vast quantities)	Assess resources; estimate opportunity costs from other uses (e.g. animal feed); develop harvesting, handling and briquetting regime and technology at various scales and degree of mechanization;product analysis; analyze costs in each of several countries; select grasses, species, and varieties.
		Grasses	Efficient converters of energy)	
		Saltbush (*Atriplex*)	Tolerates very high salinity; possible protein producer.	
Hydrocarbon-producing plants with minor residuals	Diesel fuel	Milkweed, Gopherweed (*Euphorbia*)	High genetic potential.	Little research to date.
		Neem (*Azadirachta indica*)	Traditional crop in India	Agronomy and selection almost nonexistent.
		Castor (*Ricinus communis*)	Oil can be used as diesel fuel	Little research to date; work beginning in Brazil.
		Jojoba (*Simmondsia chinensis*)	Tolerates aridity, salinity; high-value oil.	Investigate irrigation requirements; develop methods for commercialization of oil for cosmetics, pharmaceuticals.
With residual fuel		Oil Palm (*Elaeis guineensis*)	Well-known, thoroughly researched technology. Uses land unsuited to foodcrops; extraction self-sufficient for fuel; smallholder production often successful.	Compare with other crops for biomass production potential; test as diesel fuel (no special agronomic research required).
Also producing protein		Safflower (*Carthamus tinctoria*), Sesame (*Sesamum indicum*), Sunflower (*Helianthus annus*)	) Agronomy well-known; extensive breeding has been carried out on sunflower; sunflower oil is reported to be used on a commercial scale as diesel fuel.	Develop technology for refining oil for regular use as diesel (no special agronomic research required).
		Buffalo Gourd (*Cucurbita foetidissima*)	See above.	

Source: R.A. Yates, "Biomass Production Technology: Current Status and Research Needs" (July 1980).

nonleguminous types. Many other areas of basic biological research hold promise for increasing the productivity of forests. These include research on the microbiological communities called mycorhiza, which are attached to plant roots, and on virus, bacterial, and fungus diseases of trees. Modern methods of somatic cell culture, including recombinant DNA techniques, could greatly speed the pace of forest research.

Energy Crops. Table 1 summarizes the classification of the principal energy crops. The most familiar of these is sugarcane, on which research goes back more than a century. Its agronomy is well known. Additional effort is required to collect genetic material. A new breeding program should be started with a view to maximizing the total biomass. The technoeconomic potential for harvesting the total biomass of sugarcane should be evaluated. Research on cassava, by contrast, is recent, although the agronomy for this crop is well known. The research stems largely from the interest of CGIAR in cassava's role as a subsistence crop, especially in drought-prone areas. Existing research, although aimed primarily at subsistence agriculture and the production of starch for industrial purposes, is equally relevant to biomass production. Cassava culture frequently depletes the marginal soils on which it is found, and gullying can be severe on slopes. If intensive large-scale plantings are to be considered, special attention should be paid to research on soil conservation systems. Sweet sorghum is a third crop suited to the production of sugar for fermentation into fuel ethanol. It is now grown commercially on a limited scale in a few southern states of the United States. Despite its promise, there has been little research on sweet sorghum in the United States. Research on this crop in Brazil began only in the last few years. Genetic material should be collected. Field trials should also be carried out in areas in which a short growing season gives this crop an advantage over sugarcane.

Research should also be undertaken on a number of promising alternative raw materials for ethanol production, including buffalo gourd, carob, and tamarind. These crops have received relatively little attention from researchers. They need to be planted for evaluation of comparative yield vis-à-vis possible alternatives, including oilcrops and forest crops. They may have advantages over sugarcane or cassava under special ecological conditions. The potential of the sagopalm for brackish swamps, for example, is particularly attractive, although increased intensity of cultivation could result in problems of salinization.

The situation among hydrocarbon-producing crops is similar. The agronomy of some crops (notably oilpalm and sunflower) is well advanced; other crops have only been identified. Assuming that tests prove that these oils can be used as a diesel replacement, then pilot processing units can be installed for the better known plants. For the lesser known plants (especially for those suited to arid environments), comparative yield trials are required. Unfortunately, the literature is severely lacking in information about the water consumption, quality, and productivity of the arid-land plants. All work on these plants must include an evaluation of these factors.

The exploitation of straw and dry, wild grass requires the testing and selection of suitable harvesting and briquetting equipment rather than research. Censuses of the quantities of materials available are also required. They would be used, first, as combustible fuels; at some later stage, when the technology is developed, these materials may be converted to other forms of fuel. Research is also required to determine whether other plants are suitable for use in the same way as straw and wild grasses. Examples include cultivated grasses (including sugarcane) and saltbushes. In many cases, potential for extraction and use of the protein-rich sap should be investigated.

Preliminary screening is required to determine whether field trials would be justified on other plants. Certain plants that have already been identified, such as Babaçu (*Orbignya spp*), *Caryocar*, Copaiba (*Copaifera spp*), and *Jessenia*, should be checked to determine whether their potential for high yields justifies field trials. Some of the most promising species are described briefly in Table 1. 11/ A survey by major herbaria would also be useful to identify additional species.

Technologies for Conversion and Use of Renewable Energy Resources

Technologies for the conversion of renewable resources into energy can be divided into first, those for the conversion and use of biomass, and second, those for the production of thermal, mechanical, and electrical energy from direct solar, wind, and small-scale hydro. Many of these technologies will be developed and supplied by the modern sector of industrialized and developing countries after appropriate research. Other simpler and smaller scale technologies are suited, after adaptation to local conditions, to manufacture and maintenance by small workshops and artisans in villages and small towns in developing countries.

11/ See also R. Revelle, "Flying Beans, Botanical Whales, Jack's Beanstalk, and Other Marvels," in *The National Research Council in 1978* (Washington, D.C.: National Academy of Sciences, 1978).

Research into, and the development, commercialization, and diffusion of modern industrial sector processes and equipment are advancing steadily in industrial companies in developed countries. They are also taking place in a few relatively advanced developing countries. In both instances, government participation in and support of such research is a major element in national programs.

A large problem for planners and prospective users of these renewable energy technologies in developing countries is that of making informed choices among competing processes and equipment and deciding to what extent to encourage local manufacture. This task is made more difficult by the absence of agreed standards, quality criteria, and evaluation methodologies. In many cases, it is compounded by the absence of reliable data on performance under conditions typical of developing countries.

In the case of simpler technologies for exploitation of renewable energy resources, such as cooking stoves and sail windmills, the major problem is typically adaptation to local social, economic, and environmental conditions, a task that up to now has taken place principally through small, private organizations in developed and developing countries. These organizations are often closely in touch with the needs of the poor in the particular place where they work. But they are underfunded. They are also relatively isolated from each other, from the local scientific and technological communities, from the government, and from the mainstream of the economy. Such "appropriate technology" organizations can and should continue to play an important role, consistent with their capabilities. They are in need of relatively small sums to facilitate research, collaboration, communication, and development of agreed evaluation methodologies. With some exceptions they are, however, unlikely to be capable of managing on their own the problems of large-scale diffusion of these technologies.

The lack of reliable performance data and evaluated experience referred to earlier is particularly acute in the case of these less sophisticated technologies. Some of them, such as windpumpers, can be manufactured partly or wholly in the productive sector of most developing countries, although external technical assistance may be needed to help initiate the process. On the other hand, the commercialization of some of these technologies (for example, simple wood stoves) may not offer sufficient incentives to private industry.

Biomass Conversion and Use. The technologies for the conversion of biomass into usable fuels are classified in Table 2 on page 32A. A variety of processes are currently being developed--or the older ones revived--for the conversion of biomass into solid, liquid, and gaseous fuels by means of several techniques. Examples of such fuels are charcoal and densified solid fuels, ethanol, methanol, fuel oil, biogas, and producer gas. The major biomass conversion technologies include gasification, pyrolysis, anaerobic digestion, fermentation, and acid hydrolysis. Many conversions may be carried out either by large, modern installations or by simple, small-scale equipment suited to use at the village level.

In the cases of charcoal production and densification techniques like briquetting--the solid fuel conversion technologies most interesting to developing countries--the principal requirements are for adaptation to local conditions, testing, and demonstration. These are tasks for local researchers and renewable energy organizations, but they can be made easier

Table 2: TECHNOLOGIES FOR CONVERSION OF BIOMASS INTO USABLE FUELS

Conversion Process	Processed Fuel	Starting Material	Needs for Research, Development, and Demonstration		Needs for Information and Standardization	
			Major gaps	Who should fill these gaps	Large-scale technology	Small-scale technology
Extraction	Fuel oil	Oil seeds	Evaluation of existing small-scale equipment	Developing country laboratory or consulting firm	None	A
Fermentation	Ethanol	Sugar, starch	Improvement in yields and process efficiency	Industrial sector in developed and developing countries	B	A,B
Enzymatic digestion and fermentation	Ethanol	Wood	Improvements in biochemical and engineering process efficiency	Industrial sector in developed and developing countries	None	None
Gasification/ liquefaction	Methanol	Wood or other cellulose	Develop technoeconomically efficient process	Industrial sector in developed and advanced developing countries	None	None
Carbonization	Charcoal	Wood	Improvements in yields and process efficiency; adaptive research on small-scale plants	Private organizations and firms in LDCs with external collaboration	B	A,B
Anaerobic digestion	Gas/biogas (methane)	Animal and agricultural residues	Microbiological, materials and substrate research, local adaptation and societal issues	Public and private laboratories; private organizations and firms in developing countries	B	A
Pyrolysis	Oil, char, gas	Urban wastes, agricultural residues, wood	Adaptation to local conditions	Developing country industrial sector	B	None
Briquetting	Briquettes	Agricultural residues, straw	Development and adaptation of small-scale machines	Public and private laboratories, private organizations, and firms in developing countries	B	A,B
Gasification	Producer gas	Wood, agricultural residues	Process improvement, adaptation to various feedstocks, development of small-scale machines	Public and private laboratories, private organizations and firms in developing countries	B	A,B

Notes: A. Develop agreed evaluation methodology for users; encourage exchange of design and performance data among workers in different countries; review state of the art.

B. Develop and promulgate standards by which manufacturers can report performance data, and criteria by which users can judge suitability to various applications.

by making available more meaningful information on the current state of the art, likely future developments, evaluation methodologies, and experience elsewhere. In the area of conversion to liquid fuels, the technology for producing ethanol from sugar is well established but there is a need for improving the process to obtain higher yields and reduce energy requirements. Similar improvements should be made in the conversion of starchy plants, such as cassava, to ethanol, a process which is just entering the pilot plant stage. The production of ethanol and methanol from wood and agricultural residues holds much promise as a means of obtaining fuel from biomass sources that will not compete with food crops, but research is still needed to develop satisfactory processes. Considerable research in these areas is under way in the industrial countries and certain developing ones (especially Brazil); developing countries with potential for alcohol production need to be in a better position to assess the resulting technical developments in terms of their own needs.

The conversion of animal waste and agricultural residues into biogas through bacteriological action is a technology that is, in principle, particularly attractive to developing countries. Before the potential of this technology can be adequately assessed, however, there is much to be done in the way of technical research, economic appraisal, and the analysis of social and environmental implications. The focus of this activity should be in developing country institutions, but they would benefit from international support for biological research and from a multicountry testing and demonstration program that could produce the coherent technical, economic, and social data that have thus far been lacking. Technology for the generation of "producer gas" by thermochemical processes has a long history, but further research and development are required to improve the efficiency of the processes and to adapt them to different feedstocks. Considerable effort is being made to improve equipment for large-scale applications in the more advanced countries, but developing countries generally need better information with which to assess technical alternatives and choose equipment. The task of adapting small-scale equipment to local conditions is one that developing country institutions can perform well, especially if they have access to adequate information on technological developments and experience elsewhere.

Technologies for the use of biomass-based fuels are summarized in Table 3 on page 34A. Traditional technology for medium-temperature heat for cooking with biomass fuel--a pot supported over a wood, charcoal, or cowdung flame by three stones--makes inefficient use of increasingly scarce and expensive fuel. Experience in parts of the developing world demonstrate that groups closely in touch with local people (particularly women) and their cooking needs can design more efficient cooking stoves that are socially acceptable, at least in pilot trials. Such stoves can be produced from relatively low-cost materials and hold great promise for reducing wood consumption, especially in areas where wood is scarce and its cost is high in proportion to the income of the poor. The methods for diffusing these improved stoves are still untested on a large scale, however, and the social, cultural, and institutional obstacles to such diffusion remain to be understood and overcome.

Other cooking fuels derived from biomass may also be technoeconomically viable. Such fuels include straw briquettes and vegetable oil from oilseed crops. The comparative promise of such fuels, in terms of both economic and social factors, has not been adequately assessed.

Table 3: TECHNOLOGIES FOR THE USE OF FUELS DERIVED FROM BIOMASS

ms of Energy	Technology	Major Technological Gaps	Who Should Fill These Gaps	Needs for Information and Standardization
ium temperature t (100-300°C) oking)	Cooking stoves	Local adaptation and fabrication	Developing country laboratories, extension and artisan training services, private organizations	A, B, C
h temperature t ove 300°C)	Direct combustion	None		B
hanical shaft power	Internal combustion engines	More efficient alcohol powered engines: adaptation of diesel engines to biomass-based fuels	Industrial sector in developed and more advanced developing countries	A, B
	Pedal power	Development and assessment of alternative designs	National laboratories, rural extension bodies	C
	Draft animal power			C

tes: A. Develop agreed methodology for evaluation by users; encourage exchange of design and performance data among workers in different countries; review state of the art.

B. Develop and promulgate standards by which manufacturers or fabricators can report performance data, including suitability criteria for most important implications.

C. Rekindle interest in hitherto neglected technology, e.g., by educational materials, conferences, small research grants or demonstrations.

Technologies that use biomass to produce heat for industrial processes and to generate electricity are based on the direct combustion of one or another form of biomass in a boiler of suitable design. Such boilers are available, but there are no agreed standards by which to judge the performance of such equipment with biomass fuels according to an agreed format and test methodology.

Many systems which are actually or potentially available can provide stationary mechanical shaft power from fuels derived from biomass through either external or internal combustion engines. External combustion engines, operating by the Rankine cycle, may be powered by high- or medium-temperature heat from any fuel, and are suited to small- and large-scale applications, respectively.

Fuels derived from biomass can be most directly and conveniently substituted for fossil fuels in internal combustion engines. Diesel engines can be fueled by gas derived from biomass, by vegetable oils, or by other more exotic vegetable products such as the sap of the copaiba tree or the refined latex of certain species of milk-weed. Similarly, gasoline engines can be powered by liquid or gaseous fuels derived from biomass. In this relatively new application of renewable energy technology, as well, agreed standards--that is, test methodologies by which manufacturers of engines adapted to running on ethanol and other biomass-derived fuels can report performance data--do not exist.

In many developing countries, the draft animal is a major source of stationary or mobile mechanical shaft power from renewable sources of energy. Despite this dominance, the role of the draft animal is for the most part unstudied. No country has an integrated policy program or institutional framework for dealing with the technology (genetics, feed, veterinary medicine, harnesses, tools, vehicles, and so on) of draft animal power.

Human pedal power is the most elementary technology for the production of mobile or stationary mechanical shaft power. The bicycle pedal and sprocket form an efficient device for the exploitation of human muscle power, as is shown by the recent successful flight of a pedal-powered airplane over the English Channel. Bicycles are used throughout the world, especially in Asia, for the transport of peoples and goods. Low cost, ergonomically sound designs exist for low-lift pumping, threshing, and grinding by pedal power. Although pedaling is drudgery, as are other less efficient technologies--handpumps, for example, are used for irrigation in South Asia--the widespread use of such methods shows that a technology based on low-cost pedal power would find a market and could contribute to productivity. At present, however, a design available in one part of the world may be completely unknown in another, and reliable performance data are scarce.

Use of Direct Solar, Wind, and Small-scale Hydro. Table 4 on page 36A summarizes technologies that could be used to produce heat and mechanical shaft power or to generate electricity from direct solar, wind and small-scale hydro resources.

The technology for heating water by means of simple flat plate solar collectors is well known. Focusing-type collectors capable of producing higher temperatures are being designed and tested in the industrial countries. Although the amount of energy used for the production of hot water is relatively modest in most developing countries, it is needed in hospitals,

Table 4: MAJOR TECHNOLOGIES FOR USE OF RENEWABLE ENERGY RESOURCES FOR THE PRODUCTION OF HEAT, MECHANICAL, AND ELECTRICAL ENERGY

Form of Energy	Technology	Major Technological Gaps	Who Should Fill These Gaps	Needs for Information and Standardization
Heat	Solar collectors Flat plate	Local adaptation and manufacture	Developing country laboratories and industrial sector	A,B
	Focusing	Design and materials improvement	Developed country laboratories and industrial sector	B
	Solar crop drying	Local adaptation and manufacture	Developing country laboratories and industrial sector	A,B
	Solar cookers	Low cost heat storage and transmission	Laboratories and private organizations in developed and developing countries	A
	Solar ponds	Research on unlimited ponds, control of wind effects, local adaptation and fabrication	Developing country industrial and public sector laboratories	A,C
Mechanical shaft power	Commercial wind-pumpers	Local manufacture	Developing country industrial sector	A,B
	Sail windmills	Reliable performance data; comparative evaluation and improvement of traditional designs	Laboratories and private organizations in developed and developing countries	A,C
Electricity generation	Small hydro	Local adaptation and manufacture	Developing country industrial sector and government agencies	A,B
	Wind generators	Develop and test equipment	Developed country industrial sector	A,B[a]
	Photovoltaic	Cost reduction in cells and "balance of system" costs; encouragement of applications where market incentives are limited	Developed country industrial sector	B,C[b]

Notes: A. Develop agreed methodology for evaluation by users; encourage exchange of design and performance data among workers in different countries; review state of the art.

B. Develop and promulgate standards by which manufacturers can report performance data, including suitability criteria for most important applications.

C. Generate performance data by internationally managed or coordinated field demonstrations.

a. When technology nears techno-economic feasibility.

b. For specific applications for which private investment is likely to be inadequate.

restaurants, and hotels; in the homes of the better off; and in such industries as food processing. The manufacture of flat plate solar collectors is already well established in some developing countries and could be profitably undertaken in many others, if the design were adapted to local climatic conditions and locally available materials and technology were used in manufacturing. In the case of focusing collectors, the research needed to improve designs and materials is being pursued in the more advanced countries.

Crop drying frequently accounts for a substantial portion of the commercial energy used in developing country agriculture. The availability of low-cost dryers could help considerably in improving crop quality and in reducing post-harvest losses. Solar energy may be used to heat air for crop drying. A sizable number of dryers, varying principally with respect to types of air convection and air temperature, have been designed and tested on a variety of crops. Although further research is needed to optimize design, the application of solar energy to crop drying in developing countries now mainly calls for adaptation to local climatic conditions and agricultural practices. The prospects for local manufacturing should provide industrial researchers in developing countries with adequate incentives to pursue this work.

The solar pond is a promising technology for heating water close to the boiling point, a temperature sufficient to allow this method to be used for process heat, generation of electricity, or desalination. First developed in Israel (with partial funding from the World Bank), solar ponds show considerable promise for applications in developing countries because of their simplicity and low cost.

Solar cookers have been notorious failures in numerous trials, largely because of the natural resistance of people to cook in the open in the heat of the day, but also because of other social and technical reasons. The need for a technological fix to the problem of the increasing cost of cooking fuel is so pressing that there is little alternative but to continue efforts to design a low-cost system and to understand better the obstacles to its diffusion. To be successful, the design must be compatible with local cooking practices and with the comfort of the cook, as compatible as possible with social and cultural norms, and should possibly be linked to a back-up wood stove. Recent successful commercialization of such cookers in the state of Gujarat in India raises hopes that a practical approach to this problem may be possible.

Of the technologies for the production of stationary mechanical shaft power from renewable energy resources, that for commercial windmills mechanically linked to a water pump (windpumpers), is well known and proven. It requires only local adaptation, commercialization, and application in sites where it is technoeconomically feasible. Again, there is no standardized format for testing and reporting performance.

A promising "noncommercial" technology for pumping water by wind energy is that based on the traditional small-scale sail windmill. This has been used for centuries in regions of Crete, Thailand, and the Yucatan (Mexico) with reliable, steady, low-speed winds. Such windmills have been successfully installed by private voluntary organizations in Tanzania. They are technically inefficient but are cheap to construct, and can be fabricated and repaired in traditional local workshops. On the other hand, reliable cost and performance data are sparse.

Electricity may be generated from small-scale hydro installations, or from a system combining thermal energy from a solar pond or a solar thermal power plant with a prime mover. Electricity may also be generated by photovoltaic cells and by small- and large-scale wind electric conversion systems ("wind generators").

Small-scale wind electric conversion systems are already cost-effective for remote windy areas. Similarly, small-scale hydro power involves well-known and proven technology. Widespread application in developing countries, however, will require cost-effective approaches to site identification and evaluation, and equipment designed for local conditions and for low-cost manufacture by local industries. Agreed standards for testing and reporting performance would greatly facilitate the application of both technologies. In addition to the many well-known applications of small-scale electrical systems, an application of wide potential interest is the small-scale manufacture of fertilizer in remote areas by the electric arc process. This has been demonstrated recently at laboratory scale.

Large-scale (more than 200 kilowatts) wind energy conversion systems based on modern materials and aerodynamic principles are undergoing rapid research and development in technologically advanced countries. They are likely to be capable of producing electricity at competitive costs where there are suitable wind regimes, but such regimes appear to be present in relatively few areas (for example, coastal zones) in developing countries. The technology will be available to developing countries through commercial channels. Most developing countries will have to look to imported equipment, but the manufacture of certain components of wind energy conversion systems will be possible in some cases.

Photovoltaic systems, which convert sunlight directly into electricity, are especially attractive for use in developing countries because they appear to be relatively easy to maintain and are simple to operate. They are the only solar electric option commercially available today. At present, these systems are competitive only for applications requiring a small quantity of electricity remote from a grid, such as educational television, refrigerators, and communications stations. Manufacturers in technologically advanced countries--and the governments that support them--predict a rapid decrease in the cost both of the cells and balance of the system. The application of photovoltaic technology is being promoted by manufacturers based in developing countries, although few endeavor to collect performance data for comparative purposes, or for general evaluation or follow-up. 12/ A limited amount of local adaptation is needed for photovoltaic applications in developing countries, but technology and equipment will generally be available commercially. Local manufacturers in many countries, however, will be able to supply important elements of photovoltaic systems (for example, supporting structures, batteries).

Recommendations

The following specific recommendations for international support for the development of renewable energy technologies fall into two clearly defined categories: one deals with technologies for the production of biomass, and one with technologies for the production of heat, mechanical, and electrical energy from direct solar, wind, small hydro, and biomass resources.

12/ In three countries the UNDP has financed and the World Bank is executing a comparative evaluation of photovoltaic irrigation pumps suitable for small farmers, along with limited tests of a solar thermal pump, and UNDP is considering extension of this project to additional countries in a second phase.

Biomass Production Technology

Biomass production technology offers clear opportunities for a major advance in the state of the art through research. It is reasonable to expect well-designed and executed research to improve the productivity of well-known species such as sugarcane, cassava, sweet sorghum, and various fuelwood and leguminous trees, and to identify species that are potentially more productive. In addition, revolutionary developments in biological research give promise of major technological advances that might be achievable through collaboration between developing country scientists working at the frontiers of knowledge and their colleagues, either in the laboratories of developed countries or in agricultural and forestry laboratories of developing countries. Such programs would benefit almost all developing countries. Only one or two developing countries, however, could organize such efforts on their own.

An international effort would make possible an efficient program that would benefit all developing countries. Such an international program must first investigate improvements in technology for the production of biomass from well-researched species such as sugarcane, cassava, and many species of trees. In sugarcane production, for example, there is a threefold need: to breed varieties specifically for their potential as biomass producers; to collect germplasm from the border area where China, India, and Burma meet, the last area in the world with major resources of uncollected germplasm and an area in which wild varieties are in danger of disappearing; and to study regimes to maximize biomass yield through proliferation of woody material ("energy cane"). In the case of cassava, genetic materials need to be collected and soil conservation systems investigated to minimize soil depletion.

Comparative evaluations of yield need to be made for sweet sorghum, a crop little known outside the United States, to investigate its potential advantages over sugarcane, cassava, or other fermentable crops under special ecological conditions.

Breeding programs and species trials of well-known varieties of fast-growing trees should be substantially expanded, as should research to develop improved planting and harvesting techniques. Programs should be established to test promising new species of trees, shrubs, rootcrops, and grasses in a variety of sites, and to compare their potential as biomass producers with each other and with traditional producers such as oilseeds and sugarcane.

In addition, national programs of agricultural research dealing with small farmer agriculture, the multilateral and bilateral agencies that assist them, and the international agricultural research centers funded by CGIAR, should devote increased attention to the role of trees in small farmer agriculture, both as sources of fuelwood and, in the important case of leguminous trees, of fertilizer. Further staff work and consultations with the research community, as well as with such organizations such as FAO and the International Center for Research in Agro-Forestry, are needed before detailed proposals can be made in this area.

Finally, with respect to both tree growing and energy crops, there is a need for an international program of mission-oriented basic research to explore the potential of new developments in genetic engineering, somatic cell culture, biochemistry, microbiology, and physiology to open new avenues of biomass production research.

Use of Direct Solar, Wind, Small Hydro, and Biomass

The bulk of the technologies for the use of renewable energy in developing countries to produce heat, mechanical and electrical energy from direct solar energy, wind, small hydro, or biomass-based fuels are based on well-known principles. However, even familiar technologies need to be adapted to specific circumstances in developing countries. In the case of some technologies, widespread application in developing countries depends on further scientific progress. Bilateral aid programs and national energy programs in developed countries should, among other things, encourage local investors and entrepreneurs to develop technologies for use of renewable energy resources that are particularly suited to the needs of developing countries.

In the case of technologies that mainly require adaptation to the circumstances of developing countries, the major task for the international community is to support national capabilities and programs of research, development, commercialization, and diffusion. This support should include efforts to adapt smaller scale technologies to local needs by private organizations devoted to community development or to "appropriate technology."

In the case of most of the technologies that require further scientific progress, much research and development are already under way in the more advanced countries. The primary problem is to ensure that the resulting technological advances are accessible to developing countries that can benefit from them. One approach would be to establish independent international industrial research and development programs in these areas. A number of possible practical as well as political difficulties appear to argue against this approach. To be effective, such international research would have to include not only the design and testing of conceptual prototypes, but also close collaboration with potential manufacturers in developing manufacturing prototypes and involvement in the commercialization of the product. These programs require close working relations with the productive sector, and this is difficult for a publicly owned institute even at the national, let alone the international level. Moreover, such international research might be open to the objections that it would duplicate ongoing efforts in the advanced countries, on the one hand, or would divert financial and human resources from the strengthening of national programs, on the other hand.

It therefore appears that international effort in this area would be more productive if it took the form of programs for assisting developing countries to assess the usefulness, impact, and development potential of technological advances being made around the world. Such assistance would complement the assistance to local capability for research, development, assessment, and manufacture discussed under the recommendations presented in Chapter 2.

In general, the critical need in the developing countries is for policymakers to be able to assess the technical and economic aspects of processes and equipment. To do so, they require information on the present state of, and likely future developments in, technology. Such information must be sufficiently evaluated by experts before policymakers can use it to formulate strategies and make decisions. Planners, for example, need to know the best present assessment of whether diesel fuel could in the future be most economically derived from wood, from oilseeds, or from animal and agricultural residues. They also need to know how fuel from such sources is likely to compare in price and quality with conventional or novel fossil fuels. In addition, officials and entrepreneurs in developing countries need: reliable performance data on alternative pieces of equipment; evaluated experience with the technological, institutional, and social aspects of different applications of renewable energy technology; and disinterested assessments of alternative applications of renewable energy technology to high priority needs of the developing world, preferably in comparison with traditional technology or modern technology using fossil fuels.

Criteria by which to judge the suitability of alternative technologies for various applications and conditions have not, however, been developed. Moreover, in many cases, the data required do not exist. There have rarely been disinterested comparisons of alternative systems for the many applications typical in the developing world. Even the methodologies for such comparative evaluations are still under development. The present sources of data and evaluations for many technologies are the manufacturers of equipment, most of whom are in developed countries. In general, they have no agreed standards for reporting performance data, naturally convey an optimistic view, and do not adequately consider social and institutional problems.

Tables 2, 3, and 4 summarize the need for information and standardization for each of the technologies reviewed. These needs go far beyond the exchange of documentation. Rather, their major emphasis lies in measures to promote the generation of data, evaluations, standards, and other information not now generally available in the forms best suited to the needs of various classes of users.

For many technologies--such as large-scale pyrolysis and briquetting--that are likely to be embodied in equipment manufactured in the developed countries and in the modern sector of more industrially advanced developing countries the most economical approach is to develop and promulgate, in cooperation with manufacturers, users, and (as appropriate) private community development organizations, internationally agreed standards by which manufacturers would report performance data. (Such technologies are designated B in the column "needs for information and standardization" in Tables 2, 3, and 4). Standards are available for only a few renewable energy technologies such as solar collectors, and these exist in only a few countries.

For technologies that are likely to be embodied in equipment suited to small-scale manufacture in developing countries, or to artisanal or self-help construction at the village or community level, the major need is for agreed methodologies by which the user can evaluate the performance of the equipment and the broader aspects of his experience with the technology. Such methodologies can be used as a framework within which to facilitate the exchange of designs and performance data and the issuance of periodic reviews of the state of the art. (Such technologies are designated B in Tables 2, 3, and 4.) Some bilateral aid agencies are beginning to develop such methodologies for particularly technologies they are helping to promote.

For certain promising technologies (designated C in Table 4), there exist neither reliable performance data nor realistic prospects for obtaining any such data from existing or prospective national or international programs. Such technologies include solar ponds, sail windmills, and biogas. The promise of these technologies is sufficient to warrant funding and management of international comparative demonstrations in several developing countries for the purpose of generating performance data.

In the case of a few technologies, world interest has lagged to such a degree that there is a need for an international effort simply to revive professional interest. This can be done through seminars, publications, travel, demonstrations, and small research grants. Such technologies include many aspects of biomass technology, such as direct combustion of grasses, as well as draft animal power and pedal power.

Finally there is a need for a limited amount of genuinely international research on a number of special topics, for example, the optimization of solar crop dryers; microbiological aspects of biogasification; the development of a continuous biogas digestor suited to dry, straw-rich fermentation mixtures; and the development of simple, practical microcomputer programs to estimate incoming solar radiation in the field.

These proposals should be checked against expert opinion in different parts of the world. Detailed assessments that take into account likely future developments and the likely cost of the work proposed should also be made of the potential contribution of the various technologies.

4. IMPLEMENTING THE RECOMMENDED PROGRAMS

The paper concludes that there is a clear need both for additional research on renewable energy technologies and applications of special interest to the developing countries and for strengthening the scientific and technical capabilities of developing countries for mobilizing renewable energy technologies to serve their own needs. A variety of ways in which national governments and the development assistance community can help to meet these needs are suggested. In addition, it is recommended that new international programs be undertaken to:

- Diagnose, on a country-by-country basis, the technical assistance needed to strengthen national scientific and technological capabilities for renewable energy utilization;
- Support research, using both current and advanced methods, on biomass production technology of particular interest to developing countries;
- Assist in the generation, standardization, evaluation, and exchange of information on the performance in developing countries of the biomass conversion, solar, and other renewable technologies of greatest interest to them.

The international programs recommended in this report could be undertaken by various institutional frameworks. Most of the programs could be handled by institutions that already exist in the developing and industrialized countries. Central administrative staffs would be required to perform programming, coordinating and catalytic functions, but they should consist of small teams of highly qualified professionals. The principal requirements for effectively implementing and managing each of the three programs recommended are briefly discussed below. No attempt is made, however, to explore specific arrangements for sponsorship and funding or for maintaining the accountability of management to those providing the funding for the programs and to their clientele. Such arrangements are beyond the scope of this paper, except to note the need for adequate and secure finance, high professional standards on the part of the staff, and freedom from excessive political interference.

Diagnostic Assistance Regarding Local Technological Capability. There appear to be two promising institutional approaches to the provision of diagnostic assistance. One is the establishment of an autonomous international institution analogous to the International Service to National Agricultural Research (ISNAR, see footnote 5); the second, a project funded by the UNDP or the UN Interim Fund for Science, Technology, and Development. There may be advantages to the latter approach, since it would work within the framework of existing institutions and thus could avoid or minimize uncertainties, delays, and costs owing to start-up.

Biomass Production. The additional research on the growing of trees and energy crops would be undertaken in forestry research centers and agricultural laboratories, located primarily in developing countries. A number of laboratories now specializing in forestry and sugarcane, national agricultural stations, and the international agricultural institutes funded by CGIAR would all be competent to undertake such work. Direct cooperation between laboratories in developing countries and laboratories in developed countries having specific experience with particular species or research approaches should greatly increase the effectiveness of such programs and avoid the delays that would otherwise be associated with the establishment of new institutions. The trials would be funded and coordinated by a small central secretariat of professional plant scientists, backed by sufficient administrative capability to manage a large number of simultaneous research contracts in different parts of the world. The secretariat would need to collaborate closely with the FAO.

A somewhat different style of operation would be needed for mission-oriented basic research that uses sophisticated biological techniques. Most of the work would be done in university laboratories in developing countries, often in collaboration with local centers of applied agricultural or forestry research and/or with laboratories in developed countries. A possible funding mechanism would be research grants made in response to project proposals submitted by research workers and vetted by a review of groups of peer researchers under the general oversight of a scientific advisory committee. Such peer review is a common mechanism of insuring high standards of professional quality in basic research, and can be adapted to the management of basic research that is directed toward a practical goal.

Information, Assessment, and Standardization. The recommended international programs of testing, demonstration, evaluation, standardization, assessment, and research would be carried out under the guidance of a small central secretariat that would formulate policies and programs, raise funds, and provide overall technical and administrative oversight.

On matters of development and updating of its policies and work programs, the secretariat would be assisted by a technical advisory committee. This should include, in addition to internationally recognized experts in research, development, and application of renewable energy technology, people with experience in the integration of this technology in development projects and in overall energy strategy.

Programs on specific technologies and applications would be managed either by the central secretariat itself, or on its behalf by "lead institutions" that have been playing a major role in the development of the technology in question. Such lead institutions could be located in developed or developing countries, and could be national or international in character. Even if a lead institution is designated to manage a program, much of the actual research, field testing, analysis, or other specific program tasks could be carried out under contract by institutions in developing countries.

Implementation of the type of programs proposed here would constitute a major effort, much of it in fields in which there is little precedent for effective international action. Pilot programs are therefore recommended for a few technologies in order to experiment with different modes of operation and to assess the usefulness of the idea in practice. Possible candidates for such an initial program would be:

- Development of standards by which manufacturers and fabricators can report the performance of crop dryers and solar collectors.
- Development of agreed methodologies by which users can evaluate the performance of cooking stoves and sail

windmills and their broader experience with these technologies.

o Generation of reliable performance data through carefully monitored tests of biogas generators under varying conditions.

Programs concerned with small-scale technologies should make special provision for the participation and support of private "appropriate technology" organizations. These organizations have made important contributions to renewable energy technology. Despite (or perhaps because of) their small size and unorthodox approach, they have been especially effective in addressing the needs of poor people. An effort should be made to develop special flexible procedures consistent with the need of these groups for relatively small amounts of money to support travel, newsletters, conferences, publications, testing, and research.

More generally, the small inventor or researcher is a major source of innovation in many fields of renewable energy resource development. These researchers may be found in a laboratory, in an enterprise, or in a private voluntary organization in a developed or a developing country. Even well-established investigators frequently find it difficult to raise relatively small sums of unrestricted money, which are critically important to their capability to respond flexibly to new opportunities and to communicate and collaborate effectively with their colleagues. Such small grants require a special administrative style that is difficult to mesh with the requirements of large programs; it is recommended that specific mechanisms for small grants be set up to deal with such requests.

PART III

V. Considerations when licensing in a developing country

Routes of technology transfer

Basically, developing countries want technologies evolved in the developed countries or in the more advanced of the developing countries. Technology transfer has been taking place at various levels and in various ways throughout the world. The main routes through which technology is transferred can be listed as follows:

(a) A company in a developed country possessing the required technology may establish a unit in a developing country. The entire capital and technological resources required for the purpose will be brought by the company from the developed country to the developing country. The unit can be a subsidiary of the parent company or even an independent entity, completely controlled by the parent corporation. Nationals of the developing country participate in this venture to the extent of providing infrastructure, unskilled labour and protection to the investment. The benefits derived are also shared according to the inputs made by the respective participants. The bulk of the labour employed in such a unit may be from the developing country where the unit is located. However, the management will be entirely in the hands of the investors;

(b) A company in a developed country may take as a partner an organization in the developing country and establish a unit in the developing country for manufacturing a product. In this joint effort between the organization in the developed country and the organization in the developing country, nationals of the developing country provide the necessary infrastructure and also the labour and protection for the investment. Nationals of the developing country participate in the management of such a venture;

(c) An organization in a developing country can buy technology and technical and engineering services from a company in a developed country on a turn-key basis for the establishment of a plant. This company will not have any financial stake in the venture. The technological and other services it is to render will be paid for by the organization in the developing country. The engineers, scientists and managers of the company in the developed country will provide the complete know-how, engineering drawings and detailed plans; assistance in procuring the equipment and in starting up the plant; and training of local personnel in the operation of the plant. Sometimes the company will lend some of its staff for extended periods until local staff are in a position to take over the management of the plant;

(d) Under certain circumstances, the Government of a developed country can make technology available to a developing country on a government-to-government basis on terms that may be less onerous than terms negotiated between two private organizations. Such help could be for establishing significant infrastructure such as

developing the food industry–projects that directly affect the lives of the population. In such cases, the Government of the developed country may engage one or more domestic companies for this purpose, but the negotiations for parting with this technology and the services are conducted under the auspices of the donor and receiving Governments;

(e) A developing country itself may have developed the basic technology but may not be able to do the detailed engineering or to produce the equipment necessary for the establishment of a unit for manufacturing the goods based on this technology. In this case, the developing country may negotiate with an engineering firm in a developed country for its services, namely, detailed engineering of the process, the purchase of the equipment and the establishment of the unit;

(f) When the infrastructure and the technical capabilities in the developing country are at a fairly high level, the help required from a developed country may be quite small. It may be no more than having an organization look over the detailed engineering drawings and plans already prepared by the institutions functioning in the developing country.

Depending upon the degree of industrialization in the developing country, the transfer of technology takes place in one or more of the ways described above. However, several practical problems are connected with each of these systems of transfer, and these difficulties are reflected in the foreign licence agreements.

Guidelines for technology transfer

In any legal relationship, the respective rights and obligations of the parties should be clearly defined. International licence agreements pose special challenges in this regard, since they involve parties of different nationalities, frequently separated by thousands of miles, and they are usually intended to cover performance over several years.

When the licensee is an enterprise in a developing country, additional factors have to be taken into account. First, many types of services–banking, insurance, transportation, communications and distribution networks–are likely to be much simpler than they are in commercially advanced countries. Climatic conditions may have an important effect. Cultural traditions in the country of the recipient should also be sensitively appreciated.

Prospective licensors should, in addition, be keenly aware of certain attitudes that are now becoming established as the basis of policies in many developing countries. As recently as 10 years ago, licensors were virtually unrestrained in their dealings with enterprises in these countries. Antitrust laws, which must always be considered when licensing in the United States and which have just been introduced in the European Economic Community, were unknown in the developing countries. In these countries enterprises seeking new technology were inexperienced and frequently over-ambitious about the types of projects they could effectively handle.

A new breed of technocrats in many developing countries has done much to right old imbalances. They have been educated in the antitrust doctrines of the West and, therefore, frown upon attempts by licensors:

(a) To fix prices at which the licensee can sell the licensed products or goods made with a licensed process;

(b) To impose tying clauses forcing licensees to purchase from the licensor unpatented raw materials that are freely available elsewhere;

(c) To oblige the licensee to acquire certain technology, already freely available in the recipient country, as part of the larger package;

(d) To require a licensee to use trade marks of the licensor under conditions that do not enhance the licensee's chances of succeeding in the local market;

(e) To insulate the licensee from reasonable export markets;

(f) To charge a royalty or otherwise provide for remuneration to the licensor that is unreasonably high in the circumstances.

Prohibitions against these practices have been incorporated into legislation that has been adopted, in varying forms, by many countries, including the member countries of the Andean Group and Argentina, Brazil, India and Mexico. Procedures have been established for examining both existing and new agreements in the light of established criteria. The regulations cover licences between unrelated parties and technology transfers to joint ventures and to controlled subsidiaries. In most cases, these procedures have required the organization and staffing of new government administrative bodies or the substantial reinforcement of old ones.

A few principles to be followed in the transfer of technology may be suggested:

(a) The technology to be provided should be appropriate to conditions in the developing country. In some cases, this would mean that the latest and most advanced version should be provided; in others, simpler or more labour-intensive versions would be more suitable;

(b) The proprietor should be obliged and capable of providing the needed training of key personnel in the developing country. Some of this training may be given at the headquarters of the proprietor, where the trainee can better appreciate the scope of what is involved. Probably the greater part of such training, however, should take place in the host country, where the proprietor's instructors can see, at first hand, the best way in which the licensed technology can be adapted to local conditions;

(c) The licensed technology should utilize, as much as possible, local resources, including raw materials, labour skills and supervisory personnel;

(d) The activity should make a contribution to the economy of the host country that is greater than mere import substitution. Thus, the possibility of producing exports that will earn a substantial amount of foreign exchange should be a goal. Realistically, the desire to export should be tempered by an appreciation that the proprietor may have existing interests in some of the potential export markets that he would not wish disturbed;

(e) Importing the licensed technology should have some positive side effects,

On the other hand, such technology should not tend to destroy any cultural, historical or ecological situation existing in the country that should be preserved.

Licence agreements with organizations and enterprises in developing countries should contain provisions that can accomplish the transfer of technology efficiently and without creating areas of uncertainty that can become bases for future disagreements. Even if the recipient entity is a joint venture, partially owned by the proprietor, it is wise to define clearly the conditions of the technology transfer in a formal agreement. The points discussed below should be covered.

Define the technology

The parties should be clear about the information to which the recipient is entitled. The agreement should indicate whether everything the proprietor owns in a specific field is included or only certain versions or embodiments thereof, and also what rights (if any) the recipient may have to improvements or additions to the technology that become available to the proprietor in the future.

Describe the territory and the degree of exclusivity

If the recipient assumes (as is usual) that his rights are to be exclusive in his home country, it should be appreciated that other licensees of the same proprietor will require the same arrangement. Nevertheless, some reasonable provision regarding export territory can usually be worked out. One formula is for the recipient to permit the proprietor to "co-ordinate" export sales. Another approach, more favourable to the recipient, is to permit export anywhere except to countries in which the proprietor has granted, or may grant, exclusive rights to a third party.

Provide thoroughly for the technology transfer and training

A crucial provision of a licence that frequently is not emphasized enough concerns the actual transfer of the technology and training in its use. Several points to be considered in this connexion are:

(a) Planning, construction, plant layout and start-up of production facilities. Should this aspect of the work be a turn-key operation? Can the recipient or other local interests appropriately participate in it? Have reasonable deadlines and performance guarantees been provided?

(b) Provision of blueprints, operating manuals and other necessary production and marketing information. These materials should be delivered promptly and perhaps be provided in several versions, designed for persons at different levels of responsibility;

(c) Procedures for thorough and perhaps extended training. The training might be given first to a cadre of supervisors and then extended to include all other key elements of the work force;

(d) Support from the proprietor. The proprietor should maintain back-up

phases of operation. He might even be required to have representatives present at strategy meetings held at the premises of the recipient.

Tailor production to capabilities and needs

It may be that the best way to proceed at the outset is to assemble knocked-down kits, or to repackage from bulk, rather than to begin total manufacture of items covered by the transferred technology. Or, the recipient may produce only the models that are most needed locally and perhaps import the rest. At the outset, the licensee should focus his efforts on the areas of greatest priority, with the understanding that activities should then expand consistent with growing needs and capability.

Install strict quality control procedures

One of the most valuable assets of any producer is a reputation for high quality, and a negative image in this connexion is hard to live down. The fact that Japanese producers were able to acquire a reputation for excellence was one of the principal reasons for the rapid international acceptance of Japanese goods. Developing countries should be aware of the importance of quality, both for goods intended for domestic consumption and for exports.

Provide for a local research and development programme

Employees of companies receiving technology, aware of local conditions, frequently have good ideas for applications that can have value locally and perhaps also in other countries. Work on such projects can also create good licensee morale and increased commitment, particularly if those responsible for valuable improvements are rewarded generously.

Establish effective reporting requirements

The lines of communication between the parties should be strong and open for best results. The licensee should be required to report to the proprietor periodically–perhaps monthly, and no less than quarterly–describing sales and remuneration owing, marketing efforts and the status of any research being undertaken. The reporting may be in accordance with a mutually agreed upon format, which would make it possible to compare later reports with earlier ones from the same licensee, and to measure his performance against that of third parties who are licensees of the same proprietor in other areas. The degree to which these reports are truly informative often has a direct effect upon the value of the continuing

Obtain prompt approval (and, if possible, active support) from the Government of the host country .

The licensee should take the lead in "selling" the transaction to his Government. Indeed, it is usually advisable to inform the Government of the proposed terms of the agreement to obtain provisional approval even before it is finalized. The speed and efficiency with which this approval can be obtained can have a direct bearing on the continued enthusiasm of the proprietor. Nothing is better calculated to spoil a budding relationship than long delays and renegotiations with the host Government because the recipient has failed to prepare the ground thoroughly.

Summary

All the foregoing provisions are usually included in licensing arrangements between parties who are both located in developed countries. These provisions have been singled out for special comment here, however, since they are not only particularly important when the licensee is located in a developing country, but also because the procedures often need to be expanded to promote a good relationship between licensor and licensee. Other contractual provisions commonly included in licences apply equally to both environments. For the sake of completeness, these are listed as follows:

(a) The licensee is bound to keep confidential the trade secrets and other information outside the public domain made available under the arrangement;

(b) If trade marks are involved, procedures for marking legends, quality controls by the proprietor and packaging procedures should be established. Patent notices should also be affixed where patent licences are granted;

(c) The possibility of infringements of the licensed technology, either by the licensee or by a third party, should be anticipated and the respective responsibilities of the parties established;

(d) The basis of remuneration should be clearly defined, as should procedures for prompt payment;

(e) The period of the agreement, as well as possibilities for renewals or extensions, should be specified. Rights upon termination should also be set forth;

(f) In the event of defined breaches of the agreement, remedies should be clearly stipulated, including the possibility of arbitration if the parties prefer;

(g) A variety of standard clauses can be inserted to cover several possible problems. Usually the licensor will try to include the following:

> Should the agreement be terminated by the licensor for any reasons specified herein, the licensee shall not be able to claim from the licensor any damages or compensations for losses, or expenses incurred, or for lost profits.
>
> Termination of the agreement for any reason shall not affect *(a)* obligations, including the payment of any fees, which have accured as of the date of termination, or *(b)* those obligations which, from the context of the agreement, are intended to survive its termination.
>
> Neither party shall be in default hereunder by reason of its delay in the performance of or failure to perform any of its obligations hereunder if such delay or failure is caused

military authorities, compliance with Governmental laws, rules and regulations, delays in transit or delivery, inability to secure necessary Governmental priorities for materials, or any fault beyond its control or without its fault or negligence.

Any waiver by either party of a breach of any term or condition of this agreement shall not be considered as a waiver of any subsequent breach of the same or any other term or condition hereof.

This agreement contains all the understandings and representations between the parties relating to the matters referred to herein, supersedes any agreement previously entered into between them with respect thereto, and may be amended only by a written supplement, duly executed on behalf of the respective parties.

If any provision of this agreement is declared void or unenforceable by any judicial or administrative authority, this will not *ipso facto* nullify the remaining provisions of this agreement unless the licensor, in its discretion, decides that such declaration goes to the heart of this agreement, in which event this agreement shall terminate on thirty (30) days' written notice from the licensor to the licensee.

Some or all of these clauses are usually found to be appropriate by the parties to avoid possible misunderstandings.

Energy:

The capacity for doing work. It is measured in ergs, joules, calories, BTUs, horsepower, foot-pounds, tons of coal equivalent or barrels of petroleum, according to the process being considered. Kinetic energy is a measure of the energy stored in a moving body. Potential energy is the result of gravity. The higher the body is the more potential energy it has; and potential energy can be transformed into kinetic energy by lowering the body.

Power:

The rate of work. It is measured normally in watts. A Megawatt is a million watts, a Gigawatt is a 1000 million watts and a Terawatt is a million million watts.

1 Watt is 1 Joule per second.

1 Joule is the work done when 1 kilogramme is lifted vertically through 1 metre against gravity at sea level.

1 Calorie is the amount of energy which will raise the temperature of 1 gramme of water by 1 degree Centigrade.

1 Calorie = 4.18 Joules.

1 Kilocalorie = 1,000 Calories.

Conventional energy:

Energy sources which have hitherto provided the bulk of the requirements for modern industrial society, i.e. coal (including lignite and peat); petroleum (including fuel oil, gasoline, kerosene, diesel fuel, natural gas and liquefied petroleum gas); and electricity generated by burning one or other of these fuels, or from hydro or nuclear power. Wood is not included in this category although it was extensively used in the past, and still is to some extent, for industrial purposes.

Commercial energy:

Any energy form sold in the course of commerce or provided by a public utility. The term is virtually synonymous with conventional energy. Wood and other traditional fuels (see below) are not included although they are widely traded.

Primary energy:

An energy form in which there has been no chemical transformation before use. The term is of significance principally in relation to electricity generation, where hydropower is regarded as primary energy and thermal-generated power as secondary energy. Nuclear power is commonly referred to as primary energy although this does not accord with a strict interpretation of the definition.

Renewable energy:

An energy form, the supply of which is partially or wholly regenerated in the course of the annual solar cycle. Thus solar and wind energy, hydropower, and fuels of vegetable origin are regarded as renewable; mineral fuels and nuclear power are not.

Biomass fuels:

Combustible and/or fermentable material of vegetable origin, for example wood, charcoal, corn cobs, cotton stalks, rice husks, dung cakes.

Traditional energy:

Those energy forms generally used in "traditional" or pre-industrial societies. They are largely synonymous with biomass fuels and the term is generally regarded as excluding mineral fuels and hydropower, despite the fact that water wheels have been in use for over 1,000 years.

Economic and Social Commission for Asia and the Pacific, Bangkok: Renewable Energy Planning: Methodological Aspects of Assessment of New and Renewable Source of Energy and Integrated Planning, Bangkok, 5-30 August 1985, United Nations, March 1987.

Niculescu, I. and Piva, G. (Eds.): National Energy System, International Centre for Advanced Technical and Vocational Training, Turin, 1984.

Ezio Bussoletti: The General Philosophy of Energy Planning, FINMECCANICA, 1987.

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World Bank: Renewable Energy Resources in Developing Countries, Washington, D.C., USA, January 1981.

Ente Nazionale per l'Energia Elettrica: Ricerche su Fonti Alternative e Integrative e Nuove Utilizzazioni, Research on Alternative and Integrated Energy Sources and New Utilizations, Ente Nazionale per l'Energia Elettrica, a cura della Direzione Studi e Ricerche e l'Ufficio Stampa e P.R.

Agarwal, Anil: Introducing New Technologies - I. Try-Asking the Women First, Centre for Science and Environment, New Dehli, India, 1982.

Agarwal, Anil: Introducing New Technologies - II. Try Asking the Women First, Centre for Science and Environment, New Dehli, India, 1982.

Elmendorf, M.: Women - the Underused Human Resource: Education and Training of Women for Community Participation, Paper submitted to the Simposio Regional sobre Recursos Humanos para el Decenio Internacional del Agua Potable y del Saneamiento Ambiental, Panama, 26-30 July 1980.

Mary Elmendorf and Patricia Buckles: Appropriate technology for water supply and sanitation: sociocultural aspects of water supply and excreta disposal, Washington, D.C., World Bank, 1980.

El Wardani, S.: Women and IDWSSD, Focus on Technical Systems and Training, Paper submitted to the INSTRAW Interregional Seminar on Women and the IDWSSD, Cairo, 12-16 March 1984.

Kalbermatten, J.M.; Julius, D.S.; Gunnerson, C.G.: A Summary of Technical and Economic Options, World Bank, Appropriate Technology Series No. 1A.

Kalbermatten, J.M.; Julius, D.S.; Gunnerson, C.G.: Technical and Economic Options, World Bank, Appropriate Technology Series No. 1A.

O'Kelley, E.: Simple Technologies for Rural Women in Bangladesh, United Nations Children's Fund (Dacca, Bangladesh), Women's Development Programme, 1977.

1. IDENTIFY THOSE NRSE TECHNOLOGIES WHICH WILL MAINLY BE USED BY WOMEN AND THOSE WHICH WILL CONTRIBUTE TO THE IMPROVEMENT OF THEIR SOCIO-ECONOMIC CONDITION.

2. LIST THE MAIN CONTRIBUTIONS OF WOMEN IN THE CHOICE OF TECHNOLOGY FOR NRSE PROJECTS.

3. INDICATE HOW YOU ENVISAGE TO MEET EXISTING CONSTRAINTS FOR PARTICIPATION OF WOMEN IN THE IMPLEMENTATION OF NRSE PROJECTS AND PROGRAMMES.

4. LIST THE ACTIVITIES YOU WOULD INCLUDE AND PERFORM TO ENLARGE WOMEN'S PARTICIPATION IN THE CONSTRUCTION, OPERATION AND MAINTENANCE STAGES OF NRSE PROJECTS.

NAME OF PARTICIPANT

....

INSTITUTION

....

OCCUPATION

....

COUNTRY

....

DATE

....

Mark the box which corresponds best to your opinion on each question.

1. Your professional interest in the particular topic included in this modular unit was:

   high ☐ ☐ ☐ ☐ low

2. The objectives of this module were:

   clear ☐ ☐ ☐ ☐ not clear

3. Would you say that the objectives of this module met all, some or none of your expectations?

   3.a) Which objectives were not met?

3.b) Explain briefly why the objectives were not met.

4. The contents of this module were:

well structured ☐ ☐ ☐ ☐ badly structured

4.a) If they were badly structured, explain why.

5. The terminology in this module was:

easy to understand ☐ ☐ ☐ ☐ hard to understand

6. The visual material (slides, drawings, diagrams...) used in this module was:

clear ☐ ☐ ☐ ☐ confused

useful ☐ ☐ ☐ ☐ useless

7. The checklists have covered the subject studied:

completely ☐ ☐ ☐ ☐ not at all

8. The checklists were:

useful	☐	☐	☐	☐	useless
too simple	☐	☐	☐	☐	too complicated
sufficient	☐	☐	☐	☐	insufficient

9. Studying this module enabled you to learn:

many new things	☐	☐	☐	☐	nothing new

10. The knowledge acquired through this module will, in your present profession, be:

useful	☐	☐	☐	☐	useless

11. The knowledge acquired through this module will, in the near future, be:
(Reply to this question only if the answer to question no. 10 is negative)

useful	☐	☐	☐	☐	useless

12. List the topics you would like to have treated more extensively:

1) ....

2) ....

3) ....

13. List the topics you would like to have treated to a lesser extent:

1) ....

2) ....

3) ....

14. List the topics not included in this module which you think are of particular interest to your profession:

    1) ....

    2) ....

    3) ....

15. List any suggestions for improvement of this training module:

    ....

    ....

    ....

    ....

    ....

    ....

This evaluation questionnaire should be sent to:

UN/INSTRAW
P.O. Box 21747
SANTO DOMINGO
The Dominican Republic

TRAINER'S GUIDE

HARDWARE

1. Overhead projector
2. Screen
3. Slide projector, 24 mm with synchroniser
4. Blackboard
5. Flipcharts (optional)
6. Tape recorder

DOCUMENTS TO BE USED BY THE TRAINER

See "Module Structure", page 2

DOCUMENTS TO BE DISTRIBUTED TO TRAINEES

EWIII-1.1: Target groups

EWIII-1.2: Objectives

EWIII-2.1: Table of contents

EWIII-2.2: Text

EWIII-2.3: Additional reading

EWIII-2.4: Glossary

EWIII-2.5: Bibliography

EWIII-3.1: Checklists on key issues for group work

EWIII-3.2: Evaluation questionnaire

KEY POINTS	TRAINING METHOD AND ACTIVITIES	DOCUMENTS TO BE DISTRIBUTED	AVA
	INTRODUCTION		
1. Introduce NRSE	Presentation	EWIII-1.1 EWIII-1.2 EWIII-2.1 EWIII-2.2	S/S package "An Overview on NRSE - Applications"
2. NRSE can substitute for oil	Presentation		EWIII-1/2
3. Definition of forms of energy and useful energy	Presentation/ discussion		EWIII-3
4. The flow from primary energy to end-use energy	Description		EWIII-4
5. Estimated future use of NRSE	Analysis		EWIII-5
	PRESENTATION		
6. The solar energy definition: potential use	Presentation		EWIII-6
7. Solar energy conversion	Description		EWIII-7
8. Solar energy technology applications	Description/ discussion		EWIII-8
9. Hydropower generation scheme	Description		EWIII-9
10. Hydroelectric potentials	Presentation/ analysis		EWIII-10/11

KEY POINTS	TRAINING METHOD AND ACTIVITIES	DOCUMENTS TO BE DISTRIBUTED	AVA
11. Hydrotechnology for large and small plants	Analysis/ discussion		
12. Power from the sea	Description/ definition		EWIII-12
13. Geothermal energy	Description		EWIII-13
14. Installed geother-mal capacity	Description/		EWIII-14/15
15. Wind power	Description		
16. Types of wind machines	Description		EWIII-16/17
17. Technical and economical considerations	Presentation/ discussion		
18. Biomass energy conversion	Presentation		EWIII-18
19. Fuelwood	Presentation		EWIII-18
20. Ethanol	Presentation		EWIII-18
21. Methanol	Presentation		EWIII-18
22. Methane	Presentation		EWIII-18
23. Pyrolysis	Presentation		EWIII-18
24. Charcoal	Presentation		EWIII-18
25. Oil producing plants	Description		
26. Potential ener-getic contribu-tion of biomass	Presentation/		EWIII-19

KEY POINTS	TRAINING METHOD AND ACTIVITIES	DOCUMENTS TO BE DISTRIBUTED	AVA
27. Peat	Description		
28. Oil shale	Description		
29. Tar sands	Description		
30. Electricity generation with NRSE	Presentation/ discussion		EWIII-20/21
31. Conditions for full exploitation of NRSE potentials	Discussion		EWIII-22
32. Women's role in the choice and adaptation of technology	Introductory presentation		
33. The energy technology system	Presentation		EWIII-23
34. Key of success of community energy projects	Discussion		EWIII-24
35. Main factors discouraging women's participation	Discussion		EWIII-25
36. How to pay attention to women	Presentation/ discussion		EWIII-26
37. How to involve women in choice of technology	(Presentation/ discussion) Brainstorming		EWIII-27
38. Role of women's organisations	Discussion		EWIII-28
39. Women's contribution to the implementation of NRSE projects	Presentation/ discussion		EWIII-29

KEY POINTS	TRAINING METHOD AND ACTIVITIES	DOCUMENTS TO BE DISTRIBUTED	AVA
	SUMMARY		
40. Key issue checklists	Group discussion	Checklist EWIII-3.1	
41. Presentation on checklists	Plenary discussion		
	MONITORING AND CONTROL		
42. Key issue checklists	The participants will work in small groups and discuss various proposals		
43. Module evaluation questionnaire	Individual activity	Questionnaire EWIII-3.2	

NAME OF TRAINER ....

COUNTRY .... DATE ....

AVERAGE EDUCATIONAL QUALIFICATIONS OF PARTICIPANTS ....

....

.... NUMBER OF PARTICIPANTS ....

Mark the box which corresponds best to your opinion on each question.

1. To what extent has the module achieved the objectives stated?

☐ over 80%

☐ 70 - 80%

☐ 60 - 70%

☐ 50 - 60%

☐ less than 50%

2. Did the objectives meet the needs of the group?

totally ☐ ☐ ☐ ☐ not at all

3. On the basis of the objectives stated, the subject matter is:

relevant ☐ ☐ ☐ ☐ irrelevant

4. The progression of the subject matter is:
(Give reasons for your answers)

too fast ☐ ☐ ☐ ☐ too slow

5. List the topics you would like to have treated in the package more extensively:

   a) ....

   b) ....

   c) ....

6. List the topics you would like to have treated to a lesser extent:

   a) ....

   b) ....

   c) ....

7. List the topics not included in this module that you think should be included:

   a) ....

   b) ....

   c) ....

8. The technical quality of the audiovisual material was:

   high ☐ ☐ ☐ ☐ low

9. The relevance of the audiovisual material was:

   high ☐ ☐ ☐ ☐ low

10. The quantity of the audiovisual material was:

   high ☐ ☐ ☐ ☐ low

11. The sound/slide package (where applicable) was:

   too long ☐ ☐ ☐ ☐ too short

12. Your global evaluation, bearing the objectives and teaching resources of the module you have tested in mind, is:
(Give reasons for your answer)

excellent ☐ ☐ ☐ ☐ mediocre

After completion, please forward this document to:

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The Dominican Republic

EWIII-1: NRSE CAN SUBSTITUTE FOR OIL

EWIII-2: CONTRIBUTION OF NRSE

EWIII-3: PRIMARY FORMS OF ENERGY

EWIII-4: ENERGY FLOW

EWIII-5: ESTIMATED WORLD USE OF NRSE

EWIII-6: SOLAR ENERGY

EWIII-7: SOLAR ENERGY CONVERSION

EWIII-8: SOME APPLICATIONS OF SOLAR ENERGY TECHNOLOGY

EWIII-9: HYDROPOWER GENERATION SCHEME

EWIII-10: WORLD HYDROELECTRIC POTENTIAL

EWIII-11: INCREASE IN HYDROELECTRICITY GENERATION

EWIII-12: POWER FROM THE SEAS

EWIII-13: GEOTHERMAL POWER PLANTS

EWIII-14: INSTALLED LOW-TEMPERATURE GEOTHERMAL CAPACITY

EWIII-15: GEOTHERMAL ELECTRICAL GENERATION CAPACITY

EWIII-16: WINDMILLS (HORIZONTAL AXIS)

EWIII-17: WINDMILLS (VERTICAL AXIS)

EWIII-18: ENERGY FROM BIOMASS

EWIII-19: USE OF BIOMASS

EWIII-20: COMPARISON OF ELECTRICITY PRODUCTION WITH NRSE

EWIII-21: COMPARISON OF ELECTRICITY PRODUCTION WITH NRSE

EWIII-22: NRSE POTENTIAL

EWIII-23: THE ENERGY TECHNOLOGY MAIN CHARACTERISTICS

EWIII-24: THE SUCCESS OF COMMUNITY ENERGY PROJECTS

EWIII-25: MAIN FACTORS WHICH DISCOURAGE WOMEN'S PARTICIPATION

EWIII-26: HOW TO PAY ATTENTION TO WOMEN

EWIII-27: HOW TO INVOLVE WOMEN IN APPROPRIATE CHOICE OF TECHNOLOGY

EWIII-28: ROLE OF WOMEN'S ORGANISATIONS

EWIII-29: WOMEN'S POTENTIAL CONTRIBUTIONS TO THE IMPLEMENTATION OF NRSE PROJECTS AND PROGRAMMES

NRSE CAN SUBSTITUTE FOR OIL IN:

HOUSEHOLD
TRANSPORT
INDUSTRY
ELECTRIC POWER PRODUCTION

NRSE CAN SUBSTITUTE FOR

5 TO 15%

OF THE OIL CONSUMED BY DEVELOPING COUNTRIES BY THE END OF THE CENTURY

- TRADITIONAL RENEWABLE ENERGY SOURCES ACCOUNT FOR 20-25% OF TOTAL ENERGY CONSUMPTION IN DEVELOPING COUNTRIES

- 75% OF THE POPULATION OF DEVELOPING COUNTRIES USE TRADITIONAL FUELS LARGELY WITHIN HOUSEHOLDS AND PRIMARILY FOR COOKING

- MOST OF THE POPULATION HAS ACCESS TO FIREWOOD, BUT ROUGHLY 1,000 MILLION PEOPLE USE AGRICULTURAL AND ANIMAL WASTE TO FUEL THEIR COOKING FIRES

PRIMARY FORMS OF ENERGY

CHEMICAL: - FOSSIL FUELS (COAL, OIL, NATURAL GAS)

- BIOMASS (WOOD, AGRICULTURAL RESIDUES, URBAN REFUSE)

POTENTIAL: WATERFALLS AND RIVER FLOWS

KINETIC: WIND, WAVES

RADIATION: SUN

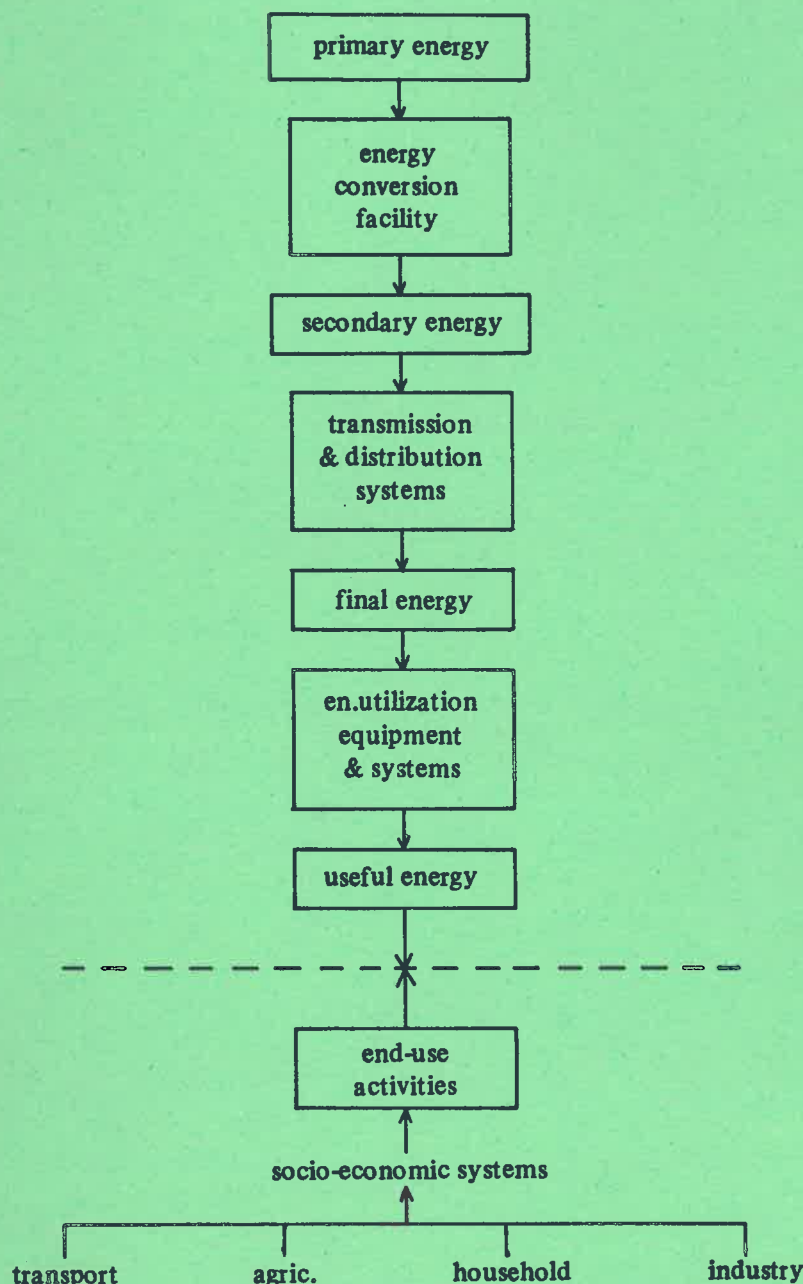
HEAT: GEOTHERMAL RESERVOIRS, OCEAN THERMAL RESERVOIRS

NUCLEAR: URANIUM

USEFUL ENERGY

HEAT

MECHANICAL ENERGY OR POWER


primary energy
energy conversion facility
secondary energy
transmission & distribution systems
final energy
en.utilization equipment & systems
useful energy
end-use activities
socio-economic systems
transport
agric.
household
industry

PRESENT AND ESTIMATED FUTURE WORLD USE OF NEW AND RENEWABLE SOURCES OF ENERGY

Source	Present use in billion (10^9) KWh	Utilization in the year 2000 in billion (10^9) kWh
Solar	2-3	2,000-5,000
Geothermal	55	1,000-5,000
Wind	2	1,000-5,000
Tidal	0.4	30-60
Wave	0	10
Thermal gradient of the sea	0	1,000
Biomass	550-700	2,000-5,000
Fuelwood	10,000-12,000	15,000-20,000
Charcoal	1,000	2,000-5,000
Peat	20	1,000
Draught animals	30 (in India)	1,000
Oil shale	15	500
Tar sands	130	1,000
Hydropower	1,500	3,000

NOTE: Figures indicating present world use fail to reveal the major differences existing between countries. However, there are not yet sufficient data available to draw up such a table on a country-by-country or even region-by-region basis. Moreover, even if the contribution of particular energy source to the world's energy production is slight, it may still play an essential role for a particular country taken in isolation. For example, peat is used for generating one third of Ireland's electricity, and geothermal energy alone may produce almost all the electricity of a region or country.

Source: United Nations A/CONF.100/PC/17

SOLAR ENERGY

THE POWER TRANSMITTED TO THE EARTH BY THE SUN CAN BE ASSUMED TO BE

1,500 TO 2,000 kWh/m^2.year

BUT ONLY A MINIMUM PERCENTAGE CAN BE EXPLOITED

IT CAN BE DIRECTLY CONVERTED INTO:

THERMAL ENERGY
ELECTRICAL ENERGY
CHEMICAL ENERGY

THERMAL CONVERSION CAN BE OBTAINED USING:

- FLAT-PLATE COLLECTORS TO HEAT WATER OR AIR AT MODERATE TEMPERATURES
- FOCUSING COLLECTORS OR CONCENTRATORS TO HEAT WATER AT HIGH TEMPERATURES BY CONCENTRATING DIRECT RADIATION ON A SMALL SURFACE.

ELECTRICAL CONVERSION CAN BE OBTAINED USING:

- SOLAR PHOTOVOLTAIC CELLS WHICH ARE SEMICONDUCTOR DEVICES WHICH GENERATE ELECTRICITY FROM DIRECT OR DIFFUSE SOLAR RADIATION.

CHEMICAL CONVERSION CAN BE OBTAINED BY:

- DISSOCIATION OF WATER INTO HYDROGEN AND OXYGEN BY MEANS OF CHEMICAL CYCLES (STILL AT RESEARCH STAGE).

SOME APPLICATIONS OF SOLAR ENERGY TECHNOLOGY

USER	NEED	TYPE OF EQUIPMENT AND TECHNOLOGY
Rural communities	Water pumping	Thermodynamic or photovoltaic pumps
	Cooking	Solar cookers
	Lighting	Photovoltaic lighting systems
	Crop drying	Solar driers, air collectors
	Small hospitals	Photovoltaic refrigerators Solar water heaters
Large villages	Water pumping	Photovoltaic or thermodynamic pumps
	Hot water	Solar water heaters
	Electricity	Electrothermal plants Photovoltaic plants
Industries	Cooling - refrigeration	Solar concentrators, solar engines
	Process steam	Solar concentrators
	Desalination	Direct evaporation (solar stills)
	Drying	Solar driers - air collectors

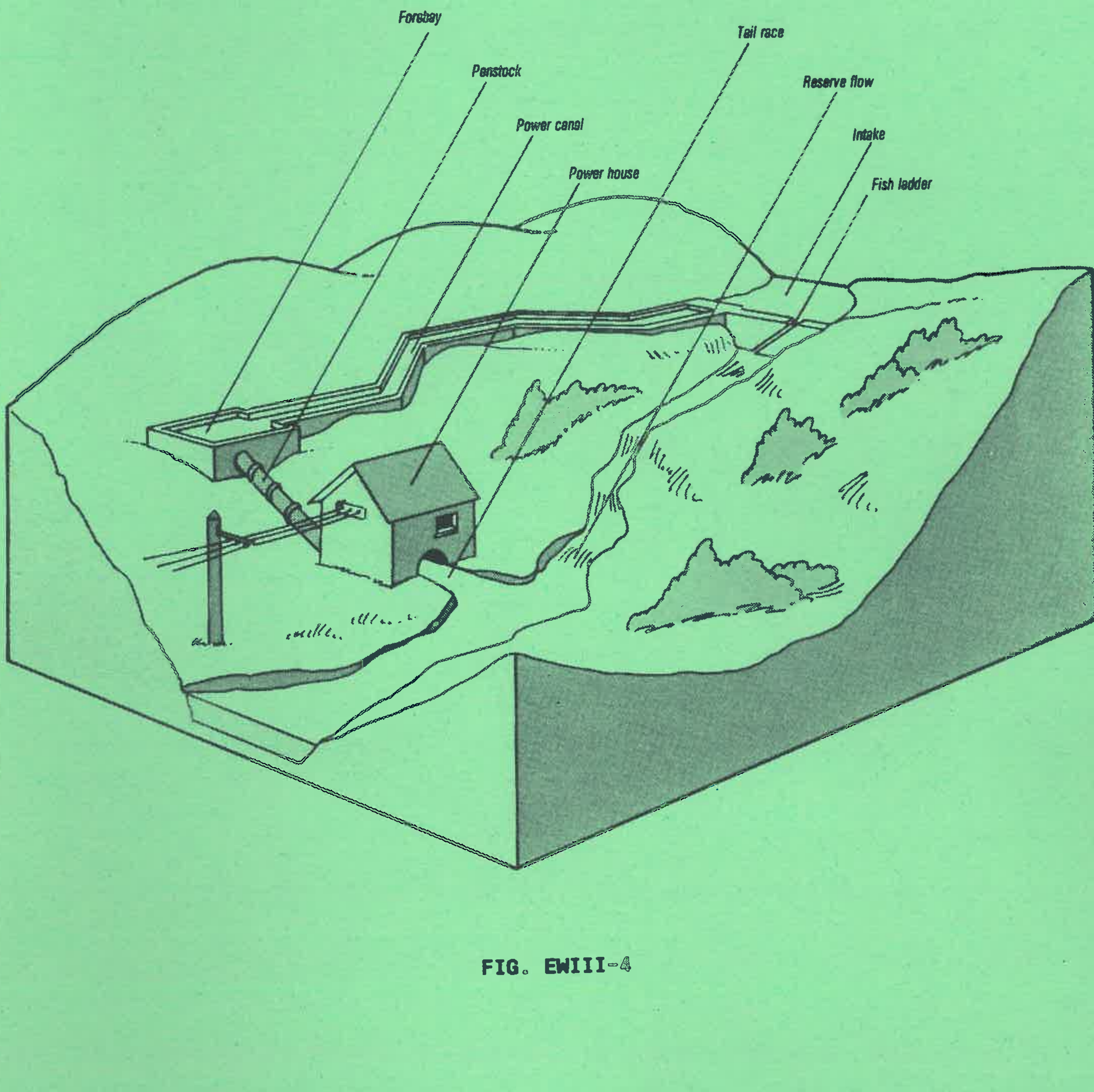

Forebay
Penstock
Power canal
Power house
Tail race
Reserve flow
Intake
Fish ladder

FIG. EWIII-4

World hydroelectric potential. While Europe is already exploiting 59% of its total hydroelectric potential, the Third World is using only 8% of its capacity. (Source: World Energy Conference, 1980)

	Technically usable potential		Present operating capacity		Percentage of hydropotential at present harnessed
	10^{12} kWh	% world total	10^{12} kWh	% world total	
North America	3.12	16	1.13	35	36
Europe	1.43	7	0.84	26	59
USSR	2.19	11	0.26	8	12
Oceania	0.39	2	0.06	2	15
NORTH	7.13	36	2.29	71	32
Africa	3.14	16	0.15	5	5
Latin America & Caribbean	3.78	20	0.30	9	8
Asia (excl USSR)*	5.34	28	0.47	15	9
SOUTH	12.26	64	0.92	29	8
World Total	19.39	100	3.21	100	17

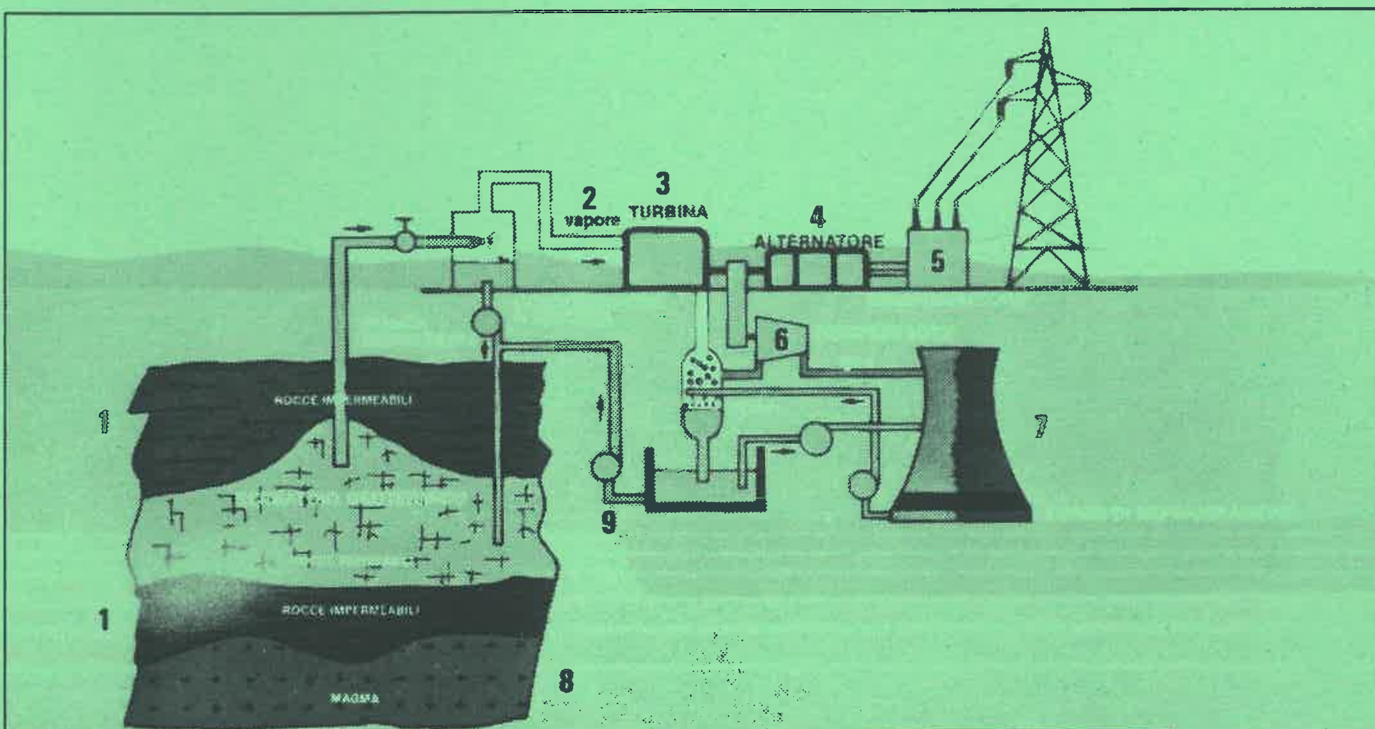
** It is not clear whether the Asia total includes China. According to Chinese data supplied to UNERG, China's usable potential is 1.9 x 10^{12} kWh and its present capacity is 0.05 x 10^{12} kWh. So China is using under 3% of its capacity at present.*

Expected increases in electricity generated from hydropower, 1976-2020. The greatest increases are expected in the Third World and China. (Figures in exajoules: 10^{18} joules) Source: World Energy Conference, 1980.

	1976	2000	(increase 1976-2000)	2020	(increase 1976-2020)
OECD countries	3.78	5.37	(x 1.4)	7.80	(x 2.1)
Centrally-planned countries (incl. USSR and China)	0.72	2.88	(x 4)	8.70	(x 12.1)
Developing countries (excl China)	1.17	4.49	(x 3.8)	11.80	(x 10.1)
WORLD TOTAL	5.67	12.7	(x 2.2)	28.30	(x 5.0)

POWER FROM THE SEAS

- TIDAL ENERGY EXPLOITS THE TWICE-DAILY MOVEMENT OF WATER CAUSED BY THE PULL OF THE MOON
- WAVE ENERGY HARNESSES THE UP AND DOWN MOTION OF WAVES ON THE SEA'S SURFACE
- OCEAN THERMAL ENERGY CONVERSION (OTEC) EXPLOITS THE DIFFERENCE OF TEMPERATURE BETWEEN WATER AT THE SURFACE AND IN THE OCEAN'S DEPTHS



1 - IMPERMEABLE ROCKS
2 - STEAM
3 - TURBINE
4 - GENERATOR
5 - TRANSFORMER
6 - GAS COMPRESSOR
7 - COOLING TOWER
8 - MAGMA
9 - REINJECTION PUMP

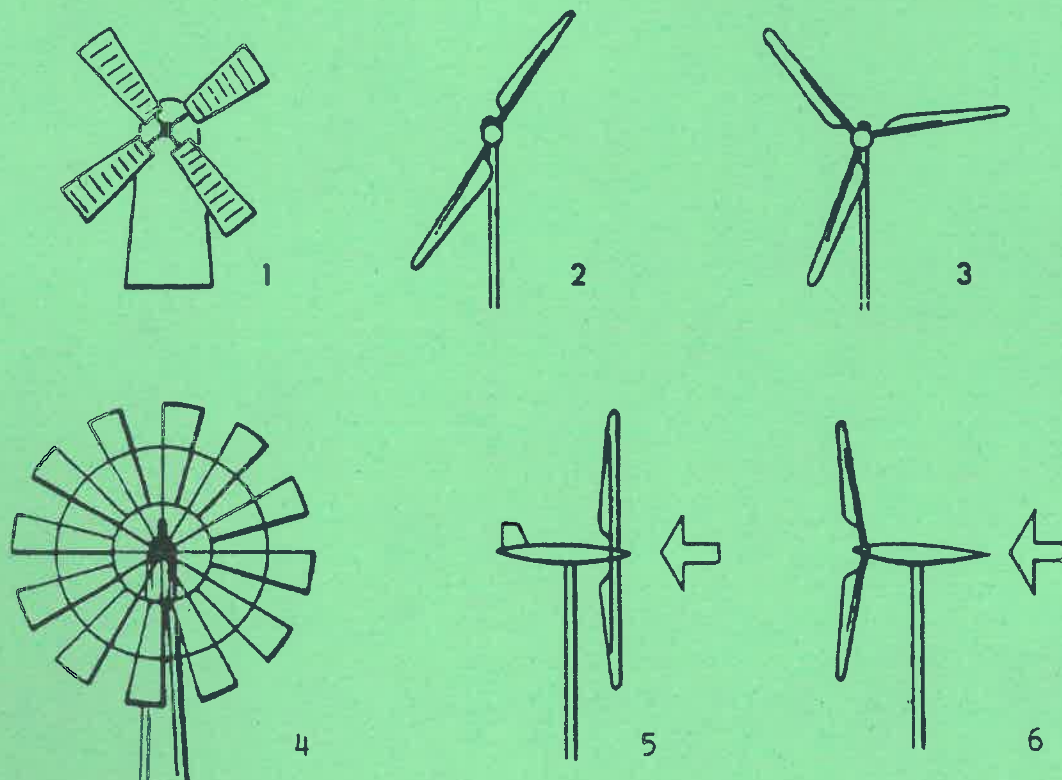
FIG. EWIII-7

Installed low-temperature geothermal capacity in 1980. Nearly 100% of the bathing capacity is in Japan, Hungary, Iceland and Italy, and 97% of total capacity is installed in these four countries plus China and the USSR. (Source: UNERG)

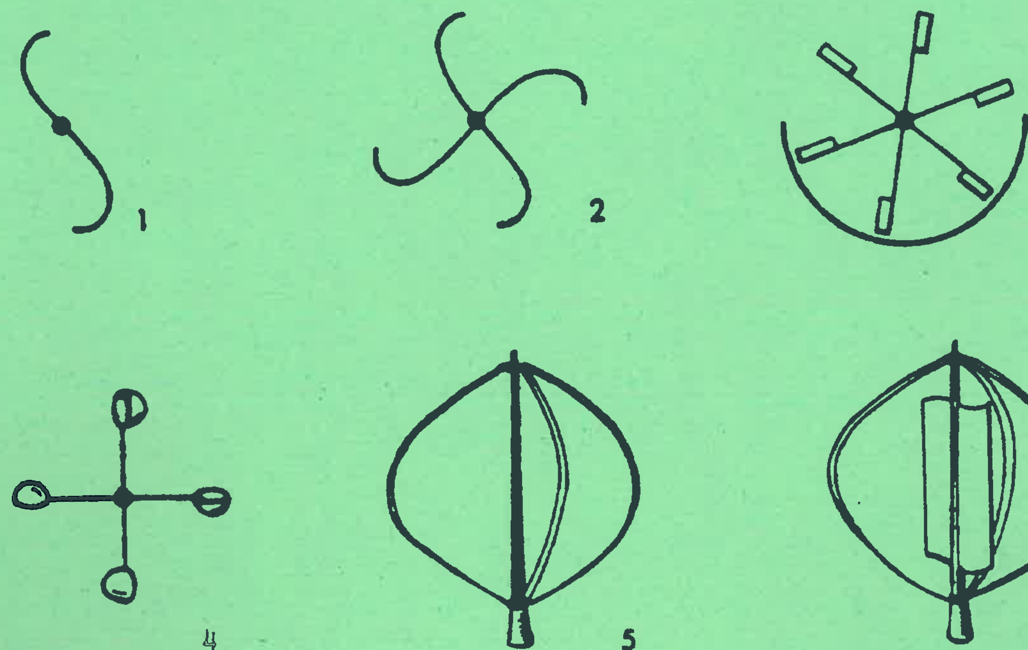
	For bathing		For other purposes		Total	
	MW	%	MW	%	MW	%
Japan	4394	82	81	3	4475	56
Hungary	547	10	619	23½	1166	15
Iceland	209	4	932	35	1141	14
USSR	0	0	555	21	555	7
Italy	192	4	73	3	265	3
China	7	0	144	5½	151	2
USA	4	0	111	4	115	1
France	0	0	56	2	56	1
Czechoslovakia	8	0	35	1½	43	1
Romania	0	0	30	1½	36	0
Austria	3	0	2	0	5	0
TOTAL	5364	100	2644	100	8008	100

Geothermal electrical generating capacity, 1980 and 2000 (estimated). (Some percentages have been rounded; less than 1% is shown as zero; a plus indicates a minimum figure.) Source: UNERG)

	1980		2000	
	MW	% of world total	MW	% of world total
USA	923	38	5824	33
Japan	168	7	3668+	21
Italy	440	18	800	5
New Zealand	202	8	382+	2
USSR	5	0	310	1
Turkey	0.5	0	150	1
Iceland	32	1	68+	0
France	0	0	15+	0
TOTAL NORTH	1771	72	11217	64
Mexico	150	6	4000	23
Philippines	446	18	1225+	7
El Salvador	95	4	535	3
Costa Rica	0	0	380+	2
Nicaragua	0	0	100	1
Indonesia	0.25	0	92+	0
Ethiopia	0	0	50	0
Kenya	0	0	30+	0
Chile	0	0	15+	0
TOTAL SOUTH	691	28	6427	36
WORLD TOTAL	2462	100	17644	100



Horizontal axis windmills have to be twisted around to face the wind. The oldest type is the Dutch post-mill (1) which stands in its own building. Double-bladed (2) and 3-bladed (3) machines are more carefully-designed aerofoils. Over a million of the US-style multi-bladed farm windpump (4) are still in use worldwide. Upwind (5) and downwind (6) aerofoils are often used to generate electricity.



Vertical axis windmills work whatever the direction of the wind. The single-bladed (1) and double-bladed (2) Savonius rotors are a well-tried design, but the flat-plate rotor (3) is easier to make, although it needs a windshield. The cupped rotor (4) is often used in anemometers (windspeed indicators). The phi-Darrieus rotor (5), or egg-whisk, was invented in France in 1927. A number of combinations of designs are now used: this one (6) is a Savonius-Darrieus rotor.

ENERGY FROM BIOMASS

<u>THERMOCHEMICAL CONVERSION</u> OF LIGNO-CELLULOSIC MATERIALS INCLUDING WOOD, INDUSTRIAL AND AGRICULTURAL RESIDUES

. DIRECT COMBUSTION
. GASIFICATION
. PYROLISIS
. DIRECT LIQUEFACTION

<u>USEFUL PRODUCTS</u>: HEAT, GAS, ALCOHOLS AND HYDROCARBONS, CHARCOAL

<u>BIOCHEMICAL CONVERSION</u> OF LIGNO-CELLULOSIC MATERIALS, AGRICULTURAL PRODUCTS AND RESIDUES, URBAN AND INDUSTRIAL WASTES WITH HIGH CONTENT OF SUGARS AND STARCHES

. ANAEROBIC DIGESTION
. ALCOHOL FERMENTATION

<u>USEFUL PRODUCTS</u>: BIOGAS, ETHANOL, METHANOL, ORGANIC FERTILISERS

BIOMASS

- CONSTITUTES AN EXTREMELY IMPORTANT SOURCE OF ENERGY CONTRIBUTING UP TO 15% OF THE WORLD'S ENERGY NEED, EQUIVALENT TO 20 MILLION BARRELS OF OIL A DAY (APPROX. THE PRESENT ENERGY NEED OF THE UNITED STATES)
- FOR ½ OF THE WORLD'S POPULATION, BIOMASS REPRESENTS THE MAJOR ENERGY SOURCE

FIG. EWIII-14

COMPARISON BETWEEN TRADITIONAL AND NRSE FOR THERMAL ENERGY PRODUCTION (AFTER FURLAN, MANCINI, SAYIGH)

TECHNOLOGY	CAPITAL COST $/kW	OP. TIME h/yr	ENERGY COST cents/kWh
Solar heating (san. water)	300-600	2000	1.5-3.0
Solar heating (space)	400-800	500	8-16
Solar cooking	200-300	500	4-6
Biogas (family)	500	contin.	0.6
Biogas (communities)	250	contin.	0.3
Alcohol from sugar cane	800	4000	2
Biomass (forest)	-	-	0.03-0.07
TRADITIONAL SYSTEMS			
Coal (25$/ton)	-	-	0.3
Oil (12$/barrel)	-	-	0.7

FIG. EWIII-15

COMPARISON BETWEEN CENTRAL PRODUCTION OF ELECTRICITY AND NRSE ELECTRICITY PRODUCTION (AFTER FURLAN, ET AL.)

TECHNOLOGY	POWER kW	CAPITAL COST $/kW	OP. TIME h/yr	ENERGY COST cents/kWh
Wind	1	3000-6000	2500	12-24
	5-15	1000-2000	2500	4-8
	3000	450	2500	2
Small hydro. units	0.05-10	1000-7000	4000	3-18
Photovoltaic	1	15000-30000	2000	75-150
CENTRALISED SYSTEMS				
Large hydro. units	250,000	800-1500	4000	2-4
Coal thermoel. plant	300,000	500	4000	2
Oil thermoel. plant	300,000	400	4000	3

NRSE POTENTIAL

THE PACE AT WHICH THE FULL POTENTIAL OF NRSE CAN BE DEVELOPED WILL BE DETERMINED BY THE COUNTRY'S ABILITY TO:

- DEVELOP ADEQUATE DATA ON SOURCES AND USES OF RENEWABLE ENERGY;
- ENHANCE THEIR TECHNICAL ABILITIES;
- DESIGN SYSTEMS THAT CAN DELIVER RENEWABLE TECHNOLOGIES IN SOCIALLY AND CULTURALLY ACCEPTABLE FORMS TO LARGE NUMBERS OF ENERGY USERS; AND
- STRENGTHEN INSTITUTIONS FOR ENERGY PLANNING AND PROGRAMMING

THE ENERGY TECHNOLOGY SYSTEM
MAIN CHARACTERISTICS

- <u>TECHNOLOGICAL</u>: FEASIBILITY, RELIABILITY, LIFE-TIME FORM OF OUTPUT, EFFICIENCY, ETC.

- <u>ECONOMIC</u>: CAPITAL COSTS FOR DEVICE, AUXILIARIES, SUPPORT STRUCTURE, INSTALLATION, OPERATION, MAINTENANCE AND REPAIR, ETC.

- <u>INSTITUTIONAL</u>: ORGANISATIONAL STRUCTURE REQUIRED, TECHNOLOGY PRODUCTION, DISSEMINATION, TRAINING, ETC.

- <u>SOCIAL</u>: BENEFICIARIES, ACCEPTABILITY, POTENTIAL EMPLOYMENT GENERATION, INTERFERENCE WITH SOCIAL STRUCTURES, ETC.

- <u>ENVIRONMENTAL</u>: CONSEQUENCES OF USING AND NOT USING THE TECHNOLOGY (e.g. ECOLOGY, POLLUTION) ETC.

THE SUCCESS OF ANY COMMUNITY ENERGY PROJECT DEPENDS UPON:

- THE USER'S CHOICE AND THEIR PERCEPTION ON THE QUALITY OF THE ENERGY SOURCE
- THE DIFFICULTY IN PRODUCTION
- THE SOCIAL INTERACTION DURING EXPLOITATION

THESE ARE FACTORS WHICH ARE OF SIGNIFICANT CONCERN TO WOMEN

THE MAIN FACTORS THAT DISCOURAGE WOMEN'S PARTICIPATION ARE:

1. SOCIO-ECONOMIC, CULTURAL AND POLITICAL FACTORS ARE NOT CONSIDERED;

2. LACK OF CONSULTATION IN PROJECT FORMULATION;

3. LACK OF ORGANISATION TO SUSTAIN WOMEN'S PARTICIPATION;

4. THE FACT THAT MEN OFTEN TAKE OVER A PROJECT WHEN THE WOMEN'S INPUT HAS BEEN IDENTIFIED AS SUCCESSFUL;

5. POWERLESSNESS OF WOMEN, PARTICULARLY THOSE WHO ARE AMONG THE LANDLESS.

HOW TO PAY ATTENTION TO WOMEN

THERE ARE TWO MAJOR WAYS FOR NRSE PROJECTS TO CONSIDER WOMEN'S PARTICIPATION IN THE CHOICE OF TECHNOLOGY:

a) BY INCLUDING INFORMATION ON WOMEN IN THE PROJECT AREA IN THE DATA TO BE COLLECTED, AND USING IT IN PLANNING; AND

b) BY ASSISTING WOMEN TO PLAY AN ACTIVE ROLE IN THE PROJECT, PARTICULARLY IN DECISION-MAKING ABOUT THE TECHNOLOGY AND DESIGN ASPECTS AND IN ACCOMPANYING TRAINING ACTIVITIES.

HOW TO INVOLVE WOMEN IN APPROPRIATE CHOICE OF TECHNOLOGY

IF WOMEN ARE TO BEGIN TAKING HOLD OF TECHNOLOGY IN THEIR DAILY LIVES, THEY COULD:

- WORK THROUGH THEIR LOCAL CLUBS AND ASSOCIATIONS TO MOBILISE COMMUNITY ACTION IN FAVOUR OF THE NEW FACILITIES;
- PARTICIPATE ON SURVEY TEAMS TO IDENTIFY COMMUNITY ENERGY NEEDS;
- CHOOSE AND TEST THOSE TECHNOLOGIES THEY WILL LATER USE DAILY;
- MONITOR OPERATION DEFECTS IN ENERGY SYSTEMS;
- KEEP A STOCK OF SPARE PARTS;
- DO ROUTINE MAINTENANCE AND MINOR REPAIRS;
- BE A LIAISON BETWEEN LOCAL AUTHORITIES AND DISTRICT/REGIONAL TECHNICAL SERVICES.

ROLE OF WOMEN'S ORGANISATIONS

- WOMEN'S ORGANISATIONS COULD ORGANISE OR SUPPORT RESEARCH PRIOR TO THE IMPLEMENTATION OF TECHNOLOGY AND ENSURE THAT ADEQUATE TECHNOLOGY IS CHOSEN FOR THE COMMUNITY, PARTICULARLY WOMEN WITH EXISTING ECONOMIC, ENVIRONMENTAL AND SOCIO-CULTURAL CONTEXT.

- WOMEN'S ORGANISATIONS CAN CONTRIBUTE TO DECISION-MAKING ABOUT NRSE PROJECTS AND DEMONSTRATION PROGRAMMES BY PROVIDING INFORMATION ON SITES, FACILITIES, TECHNOLOGIES, ETC.

- WOMEN'S ORGANISATIONS CAN ENCOURAGE THE INVOLVEMENT OF WOMEN IN THE NATIONAL NRSE PROGRAMME AT ALL LEVELS.

WOMEN'S POTENTIAL CONTRIBUTION TO THE IMPLEMENTATION OF NRSE PROJECTS AND PROGRAMMES

WOMEN SHOULD BE INVOLVED IN:

- TECHNICAL ASPECTS OF NRSE PROJECTS
- BUILDING OF FACILITIES
- OPERATION AND MAINTENANCE
- EVALUATION PROGRAMME