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NEW AND RENEWABLE ENERGIES

THEIR CONTRIBUTION TO GROWTH AND DEVELOPMENT

FRENCH GOVERNMENT PAPER

CONTENTS

INTRODUCTION

The quest for greater energy self-sufficiency is, out of necessity, one of the chief objectives of French economic policy. To achieve this, France has mounted a considerable effort for several years, aimed at the development of new and renewable energies.

It is because the problem of petroleum dependency has assumed an international dimension and because a large number of countries - especially developing countries lacking energy resources - have found themselves in difficult situations that a joint examination of the knowledge gained and the results acquired and anticipated in this area appears to be particularly timely. France believes that its effort, experience and available resources can serve the international community as a whole. It will participate in this spirit at the United Nations Conference on New and Renewable Sources of Energy.

This document elucidates the French position with respect to the contribution of new and renewable energies to economic growth and development.

Parts 1 and 2 touch on national objectives and resources in this area. Part 3 is devoted to a rapid summary of French cooperation with other countries and attempts to clarify the prospects which are emerging in this respect. In the light of this experience, Part 4 discusses what France feels to be the potential contribution of new and renewable energies to the progress of developing countries.

1 THE OBJECTIVES OF FRENCH ENERGY POLICY

Together with the energy conversation policy, recourse to alternative energies constitutes one of the basic trends of French energy policy. The effort to increase the production and consumption of alternative energies reaches out in all directions, and this - in addition to the implementation of a nuclear power programme and expanding the uses of coal - implies broadening the share of new and renewable energies in the national energy balance. The present contribution of these energies is still very small. In practice, it is intermingled with that of hydro-electric power (about 14 million toe per year or about 7.5% of France's total energy consumption) and with that of wood (3 million toe or 1.5%). However, these energies are expected to play an important rôle in the French energy balance, indeed a steadily growing rôle, as testified by the target for 1990: 24 to 28 million toe, or more than 10% of annual energy consumption.

Table 1 provides orders of magnitude anticipated by the French authorities for the contributions of these energy forms in 1990 and 2000, assuming that they are developed to the maximum extent which can be currently anticipated on the basis of the foreseeable states of the art.

Table 1

Shares of the different forms of energy

(in millions of toe)

	1979	1990 (targets)	2000 (estimated)
hydro-electric power	14	14	15
micro power plants	-	0.4 to 0.5	1
biomass (including wood)	(3)	7.5 to 9 (5.5)	12 to 15 (10)
direct solar energy	-	1.3 to 1.5	3 to 5
wind energy	-	-	0.1 to 0.2
sea energy (tidal and wave)	0.1	0.1	0.1
geothermal energy	0.06	0.8 to 1	1.5 to 2
oil shales and tar sands	-	-	0.2 to 3
TOTAL	17	24 to 26	33 to 42
% of French energy balance	9%	10%	10 to 15%

This table shows that:

- hydro-electric power, which already makes a large contribution, will not grow substantially because French sites are already satisfactorily equipped,

- large production increases are expected mainly from solar energy, both in its direct uses (domestic hot water, home heating, electricity generation) and its indirect uses (biomass), and secondly from geothermal energy.

2 FRENCH POLICY IN THE DEVELOPMENT OF NEW AND RENEWABLE ENERGIES

2.1 RESOURCES

The new and renewable energies sector in France, which comes under the Ministry of Industry (more specifically its "Direction Générale de l'Energie et des Matières Premières" DGEMP - General Directorate of Energy and Raw Materials), groups a number of public agencies.

Hence it is the DGEMP which, under the authority of the Ministry of Industry, sets up and implements French Government policy in the field of energy, including new and renewable sources of energy and mineral materials. Its activities are significantly facilitated by the fact that, in France, the State owns the bulk of the electricity production means and a monopoly on distribution, has large interests in many key sectors of the national economy, and has considerable power to influence scientific and technical research.

The Commissariat à l'Energie Solaire (COMES - Solar Energy Commission), under the wing of the Ministry of Industry, is responsible for initiating and stimulating all activities in the solar field (direct solar, wind, biomass). COMES relies on the "Agence pour les Economies d'Energie" (AEE - Agency for Energy Conservation) for spreading the use of firewood and solar water heaters. As for the use of biomass for energy purposes, COMES cooperates with the Ministry of Agriculture to mobilize agricultural and forestry resources and to develop bio-energy applications in rural areas.

The remaining areas of new and renewable energies are covered by various public and professional organizations with more specific purposes, including the following:

- Electricité de France (EDF - the French State-owned utility) for hydro-electric and tidal power,

- Bureau de Recherches Géologiques et Minières (BRGM - Bureau of Geological and Mining Research) for geothermal energy,

- Institut Français du Pétrole (IFP - French Petroleum Institute) for hydrocarbons from bituminous deposits and for alternative fuels obtained from biomass, and its subsidiary BEICIP for geothermal energy,

- Centre National pour l'Exploitation des Océans (CNEXO - National Centre for Utilization of the Oceans) for thermal energy from the sea and wave energy,

- Institut National de la Recherche Agronomique (INRA - National Institute for Agronomic Research) and Centre National d'Etude et d'Expérimentation du Machinisme Agricole (CNEEMA - National Centre for Research and Experiments on Agricultural Machinery) in the area of agricultural and forestry biomass (research, development and demonstration),

- Programme Interdisciplinaire de Recherche pour le Développement de l'Energie Solaire (PIRDES - Interdisciplinary Research Programme for the Development of Solar Energy) which carries out research activities in the area of direct solar energy and biomass, within the framework of the CNRS (National Centre for Scientific Research),

- various universities, engineering schools and specialized institutes also contribute to the training and research effort in these areas.

Table 2 gives an idea of the scale of research expenditures and investments made in 1980, by means of resources provided by the State.

Table 2

1980 budget expenditures by the government and public institutions

(in millions of francs)

hydro-electric power	2133
micro power plants	20
biomass	100
direct solar energy	450
wind energy	2
sea energy (tidal and wave)	3
geothermal energy	64
oil shales and tar sands	50
TOTAL	2822

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TOTAL	2822

This table does not include in-house corporate research and development investments. Furthermore, purchases of home equipment using new and renewable energies should be added to the above figures.

The national effort for new and renewable energies will exceed 4000 million francs in 1980. This figure includes all areas of research, demonstration, industrialization and training activities.

2.2 THE IMPLEMENTATION OF NEW AND RENEWABLE ENERGIES

2.2.1 Hydro-electric power

The current situation may be summarized by the following table.

Table 3

Extent of potential

	TWh/year	in Mtoe/year
potential resources equipped on 1.1.80	62.5	13.9
potential resources undergoing equipment	3.6	0.8
total economically equipable potential (approximate)	72	16

The large power stations belong to EDF or "Compagnie Nationale du Rhône" (CNR), and a few belong to self-serving industrial firms. Many small power plants also exist, generally belonging to self-sufficient producers who sell their power output to EDF. In actual fact, out of 1500 power stations, 1000 have an output less than 1 MW and produce a total of 1.5 TWh.

Most of the available sites are equipped, some of them for a very long time. Estimating the currently equipable potential (10 TWh) is tricky; it is based, in fact, on an economic comparison of each potential project with the thermal power production units which would otherwise have to be built to supply the same services, but remains somewhat uncertain even though it considers present conditions. Studies are under way to combine electricity production with projects for other purposes (navigation, irrigation, flood control etc) and to derive maximum benefit from modest waterways.

Measures were recently taken to stimulate the growth of small-scale hydro-electric power production:

- administrative procedures governing hydro-electric power production have been simplified and decentralized on the departmental (State) level for waterfalls of less than 4.5 MW,

- financial aid is granted to industrial users who build plants rated at under 8 MW,

- local communities are authorized to equip waterfalls.

2.2.2 Energy from biomass

The French Government assigns high priority to "green energy", which should contribute the equivalent of 4 million toe in 1990, not counting the results anticipated from firewood and charcoal (see below). For the year 2000, the minimum forecasts predict a doubling of this figure.

The priorities laid down to attain these objectives are aimed at the following.

(a) Expansion of biomass resources

Rivalry exists in the use of the soil (e.g. food crops and energy crops) and also in the use of a given product. Hence the resources must be expanded by improving forest management and by increasing the productivity of traditional crops or by planting new crops, i.e. energy crops and plantations, such as short-rotation coppices, Donax reed, which may ultimately be planted over an area of 60,000 hectares, Jerusalem artichokes, sweet sorghum, water hyacinth etc. This implies basic research and research/development operations, demonstration activities and the popularization of those techniques deemed suitable. On this matter, COMES, working jointly with industrial firms and public research institutions, will have a number of machines designed for the collection of biomass.

(b) Expansion of facilities

Expansion of facilities corresponding to energy conversion techniques currently under control or about to be in the short term. These include:

- combustion of straw,

- air gasification, which is ideal for generating stationary motive power (e.g. for electricity generation) or mobile motive power,

- methanization of liquid animal husbandry waste,

- use of alternative fuels.

(c) Rapid advances in techniques

Bring about rapid advances in techniques suitable for use in the short term. One example is the methanization of dry animal excreta, particularly gasification with oxygen which leads to the synthesis of methanol.

Based on its past experience in the area of non-petroleum fuels, France has assigned priority to methanol (over ethanol) as a partial substitute for petrol as a liquid fuel. Acetone/ butyl fermentation is also one of the research projects adopted for the production of alternative fuels.

(d) Intensification of research

This is aimed at longer-term resources or techniques: marine and lagoon crops, and processes for the direct bioconversion of solar energy, especially for hydrogen production.

In order to carry these various activities to fruition, public aid is contributed, in line with procedures that depend on the stage of development of the operation and the risks incurred.

2.2.3 Firewood

The share of firewood in France's energy balance in 1990 should amount to about 5.5 million toe.

In the next five years, the rôle of firewood will thus grow significantly, in line with the general forestry policy established by the Ministry of Agriculture. In fact, considering its estimated 1980 share of 3 million toe, the acceleration between 1980 and 1985 should be about 300,000 toe/year, and 200,000 toe/year from 1985 to 1990. Available resources which can be put to use are estimated as follows:

- still available industrial waste 0.8 to 0.9 Mtoe/year,
- forestry operation residues 0.3 to 0.5 Mtoe/year
- wood from thinning and reforestation operations 0.4 to 0.6 Mtoe/year,
- coppices aged over 30 years to be worked over a ten-year period 1.5 to 2 toe/year

or an additional potential of 3 to 4 Mtoe/year.

Intensification of the use of firewood implies that:

- the wood industries as a whole will upgrade the energy value of their wastes,
- some rural households currently heated by paraffin* will switch to firewood,
- the use of firewood in communal premises will grow (growth rate 120,000 toe/year after 1985).

A Firewood Committee was formed in June 1979 to coordinate the activities of the different organizations concerned. The "Agence pour les Economies d'Energies" (AEE) is henceforth focusing its efforts on the immediate promotion of firewood by incentives to investment for the upgrading of wood waste for energy in the wood industries and for wood-fired heating (400 F per ton of paraffin saved annually) in collective housing and local communities, and in individual homes.

The "Commissariat à l'Energie Solaire" (COMES) has made an overall estimate of available resources and has financed a number of regional studies dealing with the assessment of different types of wood usable for energy. COMES is responsible for the development of these resources and the improvement of harvesting techniques, and is laying emphasis on its activities in the areas of innovation and demonstration operations.

2.2.4 Direct solar energy

France, a medium-latitude country, has valuable renewable energy resources in the form of solar radiation (2200 hours per year on the average). COMES, which is responsible for all public activities involving research, design and support for industry in the solar energy field, has stressed the following three objectives.

2.2.4.1 Solar energy in buildings

2.2.4.1.1 Domestic hot water

Solar heating units for domestic hot water are already in use by over 60,000 households, and various incentive measures were enacted to reach a total of 600,000 solar water heaters in 1985 and a few million units by 1990 (aid for preliminary design, financial assistance etc).

To make sure that supply matches the growth in demand in terms of both quantity and quality, an industrial policy (signature of contracts with eight manufacturers of flat plate collectors who have accepted production

*USA: kerosene.

and price objectives), a training policy for installers (ten centres equipped in 1980) and a policy for establishing standards have been launched.

The major building ministries (Armed Forces, Youth and Sports, Health), aware of the need to cut operating costs relating to energy consumption, have already conducted a number of experimental operations. Jointly with the Ministry of Youth, Sports and Leisure, COMES has set up a specific demonstration operation for the solar heating of twenty-five open-air swimming pools. COMES will pursue this policy by concluding agreements on specific projects with the major building ministries.

2.2.4.1.2 Solar heating and architecture

By 1985 at least 10% of new construction will use solar energy for heating. By the year 2000 solar energy may contribute to the heating of two million housing units out of a total of twenty million.

In the area of increasing public interest and incentives, the Ministry of the Environment and the Quality of Life and COMES organized, in 1980, a competition involving the ultimate building of 5000 solar houses, which will benefit from supplementary loans to finance the extra cost due to solar installations. The three essential objectives of this competition were the following:

- to show that a solar house saves energy and is inexpensive in terms of investment and operation,
- to stimulate solar activity by organization of the market and financing guarantees,
- to improve the architectural quality of solar houses so as to ensure the spread of this type of construction.

Research activities are essential in the area of solar heating, because the goal is to find a solution to the major problem of the gap between solar energy availability and heating requirements. The chief research activities financed by COMES are concerned with interseasonal storage and thermal modelling of the home.

2.2.4.2 The photovoltaic industry

The overall production capacity of French industry exceeded 1 MW peak power output in 1980, making France, which contributed abroad to vast programmes involving pumping, solar television, rural electrification and telecommunications, second worldwide in this field behind the United States.

A public aid plan adopted in March 1980, covering a six-year period, will help to create industrial development centres in this branch of activity. This aid is devoted to research, exploratory development, industrial investment and demonstration projects. Also available is non-COMES financing, such as that provided by the "Agence Nationale pour la Valorisation de la Recherche" (ANVAR - National Agency for the Utilization of Research) and industrial policy credits granted by the Ministry of Industry.

Support for research is aimed at three objectives:

- technological research, to sustain the observed trend toward lower prices for photovoltaic modules,
- financing of research on alternatives to silicon,
- development of electronic systems to ensure a better matching of electricity production and utilization.

2.2.4.3 The solar thermodynamics programme

France has launched a vast programme involving widely diversified research and development on the overall solar thermodynamics system. Its effort is currently focused in the following three directions:

- the Themis tower power plant: rated capacity 2 MWe, primary circuit with molten salt and heat storage, 200 53 m^2 heliostats; commissioning of this installation, which will be the world's largest heliostat field, is planned in November 1981 in southern France,
- the 100 kWe distributed collector power plant: 1200 m^2 of segmented-mirror collectors, a storage unit and two organic fluid conversion loops; commissioning is planned for mid-1981 in Corsica,
- process heat generation by means of parabolic collectors: the planned demonstration operations are intended to show that it is possible, in a normal industrial environment, to operate a solar system for the production of heat that makes substantial fuel savings possible.

2.2.5 Wind energy

Experiments are continuing in this area. The French programme covers the following topics, listed by order of importance.

(a) Creation of a wind generator test zone to be made available to laboratories and industrial firms and designed to compare the performances of different prototypes or machines produced in limited numbers.

(b) Industrial development of small-sized machines with horizontal or vertical axis (rotor diameter less than 15 m, power capacity less than 20 to 20 kW) that can be used for electricity generation (output 1 to 5 kW and 5 to 20 kW), pumping, heating and desalination.

A distinction is made between machines designed to operate unattended in poor weather conditions and those designed to operate in a supervised location.

(c) Research and testing of medium-sized machines with horizontal axis (rotor diameter 15 to 30 m, power capacity 30 to 300 kW). The following can be distinguished in this case:

- wind generators designed to operate to achieve fuel oil savings on self-contained networks already equipped with diesel power plants,
- wind generators supplying an isolated network to achieve self-contained operation, with or without storage,
- multi-rotor machines,
- grouped wind generators.

(d) Development of an independent station for the estimation of wind potential.

(e) Site surveys by simulation in a hydraulic flow.

2.2.6 Sea energy

In recent years France has devoted the bulk of its effort in this area to tidal power. It is also investigating thermal energy of the seas (TES) and wave energy. It is felt in France that the economic prospects for the utilization of marine currents are poor, owing to the prohibitive cost of operating a very low water fall; moreover energy from salinity gradients is still in the conceptual stage.

2.2.6.1 Tidal power

This is the only marine energy which can be considered as having reached the industrial phase in France. The Rance tidal power station, with a

power capacity of 240 MWe, has been operating since 1967 and has given full satisfaction from the technical and economic standpoints while providing considerable experience. The kWh cost of this power station is comparable today to that obtained by a large thermal power plant.

France is also conducting preliminary investigations for the possible utilization of tidal power resources in the Chausey Islands zone. The economics and the environmental impact of this costly project, which would represent a capacity of about 12,000 MW for production of 25 TWh (about 5.5 Mtoe), are still far from having been determined as yet. Construction will in any event last about twelve years. France is also trying to give the benefit of its know-how to countries possessing favourable sites (some twenty sites worldwide).

2.2.6.2 Ocean thermal energy conversion

Ocean thermal energy conversion (OTEC) represents a considerable potential located in the intertropical zone where, in the event of the rarefication and rapidly growing cost of traditional energies, the economic value of this form of energy should materialize. The programme under way includes two phases.

(1) A feasibility study of small and medium TES power stations (1 to 15 MWe). The study has already shown that such open and closed cycle power stations are technically feasible and that they correspond to component sites already manufactured industrially. It also appears that the competitiveness of the TES kWh, by comparison with the diesel kWh, in isolated sites such as Tahiti, is already proven in the pilot plant stage for capacities lower than about 10 MWe.

(2) Implementation of a pilot project in the light of the results of the first phase and of some additional tests. This second phase will include a demonstration power station of a few MWe, serving to show effectively that TES is technically viable and economically acceptable.

2.2.6.3 Wave energy

The idea of exploiting wave energy is still in its infancy. In this respect France possesses a valuable resource on its Atlantic seaboard that justifies a research effort. The French programme is intended to assess the feasibility, operating and commercial conditions of small wave power units of under 1 MWe to meet the needs of isolated communities (islands, offshore platforms etc).

2.2.7 Geothermal energy

A distinction must be made between two types of geothermal energy usage:

- the first concerns the use of hot water at a temperature generally below 100 °C, either directly or after heat exchange; this is the "low energy" geothermal application,

- the second concerns the use of steam issuing from the earth at a temperature above 150 °C to produce electricity; this is the "high energy" geothermal application.

High energy applications offer few possibilities of development in continental France. The goals thus consist of developing operations on favourable sites in French overseas territories and of exploiting French techniques and equipment abroad. French laboratories have also launched technological research projects within the framework of tenders issued by the EEC.

On the other hand, low energy applications offer significant possibilities of economic development in France. A large share of low temperature needs (urban heating, hothouse heating, industrial requirements) can be covered by geothermal energy, in view of the scale of the resources and their ideal location in relation to consumption centres. An overall policy for geothermal energy development set up in 1973 has begun to bear fruit. It constituted an attempt to remove the main obstacles encountered and led to various measures: legislative, regulatory, financial, and those relative to geological and mining risks.

The number of projects launched has risen rapidly since 1978. Thus geothermal energy has gone from the research stage to a development stage which serves to set ambitious but realistic goals for the contribution of this source of energy to France's energy balance (0.8 to 1 Mtoe in 1990, for investments of 7500 million francs to be made by that date).

	1980	1985	1990
number of operations launched	20	150	375
number of housing units or equivalent concerned	42,000	400,000	1,000,000

2.2.8 Oil shales and tar sands

Although its tar sand and oil shale resources are relatively modest, France has spent several years in a research effort in this area,

in order to develop technologies and acquire the ability to act in order to upgrade national resources, or in connection with operations abroad. The programme to be implemented until 1985 will consist essentially of research and development work, as an industrial follow-on does not appear feasible before 1990 on French territory.

In the area of research, France, and the French Petroleum Institute in particular attach great importance to geochemical research and the characterization of heavy products, in order to enhance geological surveys and improve methods of using organic matter.

With respect to tar sands, new *in situ* processing methods are being investigated in the laboratory and are undergoing pilot tests in the field. The horizontal drilling technique, which is especially attractive for tars and deposits distinguished by a very low injectivity, is beginning to be tried out successfully. But the problems encountered by the upgrading of unconventional oils are an obstacle to the development of the use of these resources. To help alleviate this situation, France has decided to build an experimental heavy product processing unit with a capacity of 15,000 to 20,000 t/year. Moreover, investigations into the use of heavy products as industrial fuels are actively under way.

Bituminous shales were worked in France on a small scale in the nineteenth century and until 1957 but no complete inventory of domestic resources was available until the formation of the "Groupe d'Etudes des Roches Bitumineuses" (GERB - Bituminous Rock Study Group*) in 1973. Zones which are favourable to quarry working were thus identified on the eastern edge of the Paris Basin. An initial technical and economic assessment of such a working has been made. Since 1979 new research programmes have been set up. They are aimed primarily at completing the work of the GERB, particularly by an analysis of the environmental impact of a mining type operation. In addition, studies have begun on the possibilities of *in situ* extraction.

2.3 THE SPECIAL CASE OF FRENCH OVERSEAS TERRITORIES

Within the framework of the French programme for the development of renewable energies, a mention must be made of the programme applied in the French overseas territories.

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*Including IFP, Compagnie Française des Pétroles, Société Nationale Elf Aquitaine, BRGM and Charbonnages de France.

In view of their characteristics (dispersion, abundance in tropical zones etc), renewable energies can meet part of the energy needs of the overseas territories.

They can be used to cover essential requirements in isolated places (rural areas, small islands) such as water pumping and electric power supply (over 20% of homes in the overseas territories are not connected to the grid). Renewable energies can curb the rural exodus and thus facilitate the development and growth of the overseas territories.

New energies also offer significant security of supply: the sun, the wind, bagasse, wood etc, are local resources which can cover 20 to 80% of energy requirements, as the case may be. Renewable energies will thus guarantee protection against rising oil prices. In addition, many sites are favourable to high-energy geothermal applications.

Operating costs appear to be relatively limited. Equipment using solar energy or wind energy only requires minimum maintenance, whereas in a local context the scale of operating costs is an obstacle to the development of conventional energy sources.

The renewable energies programme in Polynesia

This special research and experimentation programme is funded by COMES, the French Solar Energy Commission, the French Atomic Energy Commission (as operator) and the territory of Polynesia.

Programme objectives are as follows:

- compilation of an inventory of renewable energy resources,
- experiments with "renewable energy" solutions for the islands (water production, cold production, electricity generation),
- component testing under the scientific conditions prevailing in Polynesia.

The principal projects already implemented or being set up are concerned with the following:

- solar and wind pumping at Bora Bora,
- solar air-conditioning of a building at Mururoa and at Papeete,
- electricity for hospital and housing at Tubuaïu and Tautira,
- an 18 kW wind generator (310 kWh/day) at Arutua.

3 FRANCE AND INTERNATIONAL COOPERATION IN THE SPHERE OF NEW AND RENEWABLE ENERGIES

3.1 COOPERATION WITH INDUSTRIALIZED COUNTRIES

3.1.1 European cooperation

France plays an important rôle in setting up and carrying out projects of the European Economic Community with respect to renewable energies, from the standpoint both of demonstrations and research and development.

Hence several French organizations, including COMES, participate actively in the programme launched in 1976 by the Commission of European Communities in the area of research and development covering the following:

- solar applications in housing,
- photovoltaic conversion,
- photochemistry and photobiology,
- energy applications of biomass,
- gathering of solar meteorological data,
- wind energy,
- solar energy applications in agriculture and industry,
- gas generators,
- hot granulation of straw etc.

France, jointly with the European Economic Community on the one hand and the Federal Republic of Germany and Italy on the other is involved in financing the 1 MW tower power station which was commissioned in Sicily at the end of 1980.

In this respect, an especially detailed study was made by BRGM, within the framework of the EEC, of the state of progress of research and development in the area of geothermal energy in the various EEC countries. Some investigations concerning border areas or subjects of common interest are conducted in close collaboration with member States (Belgium, West Germany, Italy). A demonstration project is planned in Greece in the area of photovoltaic conversion.

France also collaborates closely in the activities of the European Development Fund, which devotes increasing sums to new and renewable energy projects in developing countries. Meetings between research

workers of the EEC provide the opportunity for extremely useful exchanges of information.

3.1.2 Bilateral cooperation with industrialized countries

French cooperation with these countries generally occurs in the field of research. It is reflected by reciprocal training programmes for researchers. Frequent contacts are organized with the following countries:

- the United States, for the organization of joint seminars and exchanges; there are regular contacts with the Department of Energy,

- Canada, with which there have been numerous interchanges on the energy upgrading of forests and the synthesis of methanol; frequent exchanges have also taken place concerning the exploitation of tar sands in western Canada; the Canadian subsidiaries of French oil groups participate in pilot *in situ* trial workings of these deposits.

Information exchanges and visits are also frequent with Japan (geothermal energy and solar energy), Sweden (solar homes, upgrading of wood), the Federal Republic of Germany (tower type solar power plants), Greece (wind energy), and New Zealand (geothermal energy). Various contacts have taken place with the Soviet Union, and scientific cooperation is planned.

3.2 COOPERATION WITH INTERNATIONAL ORGANIZATIONS

3.2.1 United Nations

French organizations are frequently asked to participate in seminars and appraisals on behalf of various agencies belonging to the United Nations, including the following.

(a) United Nations Development Programme (UNDP), particularly within the framework of Mediterranean meetings intended to create one or more research centres.

(b) United Nations Environment Programme (UNEP), which picked COMES to be the prime contractor for a solar village in Senegal.

(c) UNIDO, for which various projects have been appraised.

(d) UNESCO, for the assignment of experts for training purposes.

(e) Food and Agriculture Organization, mainly its European commission.

(f) The Economic Commission for Africa (ECA), and the Economic and Social Commission for Asia and the Pacific (ESCAP).

3.2.2 World Bank

By virtue of a mission carried out in January 1980, France has made a contribution to the multi-annual programme in preparation, to implement the decision of the BIRD for a broadening of credits in favour of operations concerned with new and renewable energies.

3.2.3 Other international organizations

It is worth mentioning a cooperation agreement between COMES and the Latin American Organization for the Development of Energy (LAODE), contacts with the Economic Community of Western Africa, in which France has been asked to cooperate in the creation of a solar energy research centre at Bamako, the French contribution to the Asian Institute of Technology (Bangkok), and the many meetings with regional banks, Arab funds etc.

3.3 COOPERATION WITH DEVELOPING COUNTRIES

Apart from information exchanges which take place regularly in the form of seminars, missions and symposia with most developing countries, cooperative activities carried out by France cover all aspects of the setting up and implementation of the energy policies of these countries.

3.3.1 Energy planning studies

In 1980, under the auspices of the Ministry of Industry, a number of public and financial institutions formed a body for the study of energy planning problems of developing countries, called Transenerg.

Based on the qualifications of its members*, Transenerg is capable of providing the countries or organizations concerned with the assistance necessary for overall planning of all forms of energy, especially new and renewable energies, by means of technico-economic surveys of needs and resources. It can advise them on the setting up of administrative and financial organizations related to this planning.

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*AEE, BEICIP, CEA, COMES, EDF, GDF, IFE, SNEA and Sofremines.

Transenerg's activities, which are carried out within the framework of national, bilateral, multinational and international financing arrangements, are of different types:

- analysis of current and future energy resources,
- definition and preparation of programmes for the development and planning of all forms of energy,
- establishing financial and fiscal policies capable of achieving the goals set,
- training of qualified staff personnel.

3.3.2 Research and development

A major "new and renewable energies" programme involving the Ministry of Cooperation and subsequently COMES was set up in 1976. Limited to the Sahel countries in the initial phase, it was called "Sahel, Energies Nouvelles" (Sahel, New Energies). Since 1979 it has been extended to include other African countries.

This was initially (1976/1978) a research, development and applications programme, implemented in cooperation with the research and development centres of the Sahel countries: Cape Verde Islands, Senegal, Mauritania, Mali, Upper Volta, Niger, Chad and Cameroon (North).

Financed by the Ministry of Cooperation and the Ministry of Industry, it was carried out with the help of thirty French technical assistants working in various fields of renewable energies in the Sahel countries. The objectives of the programme were as follows:

- a regional research and application programme covering all Sahel countries,
- demonstration of the operational characteristics of renewable energies (solar energy, wind energy, biogas),
- applications to rural development in Sahel countries (village and pastoral water supply, irrigation, desalination, refrigerators, cold storage rooms, electricity production in rural areas).

The main projects included the following:

- photovoltaic energy: 15 pumping, irrigation and electrification installations, including the 10 kW generator of the SAN hospital in Mali,

- solar thermodynamic conversion: 123 pumping, irrigation and electrification installations, including the 80 kW solar power plant at Diré (Mali) and the 30 kW solar power plant at Bakel (Senegal), in cooperation with USAID,

- wind energy: 9 pumping, beaconing, electrification and assessment installations, including a 4 kW pumping wind generator at Sao Nicolau (Cape Verde) and one for the M'Boro (Senegal) market garden training centre,

- biogas: 10 installations for cooking and pumping in Upper Volta,

- solar drying: 2 installations.

Since 1979, Commissariat à l'Energie Solaire (COMES) has assumed responsibility for implementing the programme, which was expanded to cover:

- new sources of renewable energy: biomass, hydro-electricity, inventory of resources and experiments with available techniques,

- new operations: home, lighting, telecommunications,

- new countries: all African countries associated with the Ministry of Cooperation.

A special effort was made in 1980 to check the performance of operational installations for the benefit of future projects.

Concurrently with this scientific programme, the Ministry of Cooperation participated in financing local investigations (solar energy, micro-hydraulics, biomass, wind energy, geothermal potential) conducted in Gabon, Ivory Coast, Mauritania, Upper Volta, Madagascar, Senegal, Congo and Djibouti, together with permanent research programmes dealing with the biomass (silviculture, energy crops, synthesis of methanol, charcoal, cellulose), matters of interest to all African countries.

Various public agricultural research institutions also contributed to setting up cooperative projects and programmes such as:

- development of a small tractor-mounted gas generator using by-products (Centre d'Etudes et d'Expérimentation du Machinisme Agricole Tropical - CEEMAT, Research and Experimental Centre for Tropical Agricultural Machinery),

- synthesis of methanol by gas generator and solar synthesis (Centre Technique Forestier Tropical - CTFT, Technical Centre for Tropical Forestry),

- production of mechanical power from tropical by-products by gasification or carbonization (Centre National d'Etudes et d'Expérimentation du Machinisme Agricole - CNEEMA, National Centre for Research and Experiments on Agricultural Machinery).

The Centre National de la Recherche Scientifique (CNRS - French National Centre for Scientific Research), universities and other public research institutions signed some twenty cooperative agreements with the corresponding research institutions in foreign countries. These many pairings between specialized teams reveal a focusing of interest on:

- socio-economic studies of energy flows in ecosystems and social acceptance of new methods of collection and conversion of new and renewable energies,
- photovoltaic processes and systems development,
- development of concentrators,
- development of thermal solar collectors and their application to agriculture and housing,
- basic photosynthesis processes,
- enzymatic conversion of biomass.

3.3.3 Education and training

France (especially its engineering schools) is capable of providing a significant effort in the area of advanced adult training. The creation of an Advanced Institute for the Management of Energy Resources is planned.

The activities of the Ministry of Cooperation in the area of vocational training and university education devote an increasingly larger share to new and renewable energies. This takes the form of inter-university agreements, which have hitherto dealt with photovoltaic conversion, solar energy and biomass, or inter-establishment agreements concerning technical assistance, the granting of scholarships and some technological experiments.

In addition, the Ministry of Foreign Affairs contributes in various ways to the promotion of new and renewable energies, by means of residence, research and training grants, short-term missions, the sending of documentation and equipment, the assignment of experts and invitations to foreign scientists.

Cooperation of BRGM with developing countries in the area of geothermal energy stresses training, allowing a transfer of technology and know-how between the corresponding teams. This working method is implemented in particular during the survey phases including geological, geochemical and hydrogeological stages (Latin America, relations with LAODE and Indonesia especially).

Electricité de France (EDF) also acts on several levels:

- professional training of technicians in 133 centres located in 55 countries,
- training in France of 800 trainees per year,
- participation in the inauguration of the "Ecole Supérieure Interafricaine de l'Electricité" (Inter-African Advanced Electrical Engineering School) in the Ivory Coast.

Furthermore, "Institut Français du Pétrole", its subsidiary BEICIP, and the "Ecole Nationale Supérieure du Pétrole et des Moteurs" (ENSPM), an integral part of IFP, are carrying out a substantial training effort devoted to engineers and technicians. Hence the "Centre d'Etudes Supérieures d'Economie Pétrolière" of ENSPM examines all economic aspects of the different sources of energy. IFP has already trained more than 1000 engineers from 70 countries throughout the world. BEICIP, with the assistance of IFP, has initiated and/or supervised the creation of some 15 research and training institutions and centres abroad.

Finally, some special agreements signed by COMES and CNRS include clauses concerning cooperation in matters of education and training (creation of laboratories or institutions, training of personnel, university type exchanges).

3.3.4 Service and engineering

Services which can be rendered by French organizations and companies cover all engineering aspects of the field. These range from surveys of potential projects (prospecting, identification) to the management or supervision of construction operations (prime contractorship), including all intermediate stages of the life of the project (feasibility study, cost analyses, preliminary project, drafting and analysis of tenders, working schedule).

"Electricité de France", through its "Direction des Affaires Extérieures et de la Coopération" (DAFECO - Directorate of Foreign Affairs and Cooperation), thus performs the rôle of consulting engineer to a number of developing countries for the design and construction of hydro-electric projects. To carry out these activities, EDF benefits from the long

experience of DAFECO. Considering only the past ten years, and projects which have effectively reached the final execution stage, EDF has directed the construction of 15 hydro-electric projects (Cameroon, Ivory Coast, Gabon and Zaïre), with a total installed power output of 2262 MW in 39 generators, with capacities ranging from 4.8 to 160 MW. For the four countries concerned, it is important to note that these schemes will allow them to eliminate the need for hydrocarbons for electricity generation.

"Institut Français du Pétrole" also carries out a very active policy of scientific and technical collaboration, technical advice and assistance, with many research and development centres worldwide and also with the government authorities and national companies of different countries. Its activities are concerned with geothermal energy, geochemical assessment and techniques for the mining of bituminous deposits, upgrading of crude oils and heavy products etc.

BEICIP, an IFP subsidiary, as part of its consulting and service activities concerning high energy geothermal applications, collaborates closely with several foreign countries. It has assumed a major share in the development of the geothermal fields in Java (Indonesia), where its activities, which began in 1976, permitted the drilling of two horeholes which are excellent producers of high temperature steam. BEICIP's activities also extend to engineering consultancy to governments and national companies in developing countries, in areas of energy and the planning and supervision of industrial projects.

3.3.5 Implementation and financing

French industry is capable of supplying equipment and of carrying out work for the financing of which various arrangements are also available in France.

The Ministry of Cooperation, through the "Fonds d'Action de Coopération" (FAC - Cooperative Activities Fund), can grant a non-repayable subsidy to some developing countries for the implementation of an investment project. The "Caisse Centrale de Coopération Economique" (CCCE - Central Bank for Economic Cooperation) grants loans at preferential rates, repayable over very long periods. The Ministry of the Economy, within the framework of financial agreements, can also grant Treasury loans on highly advantageous terms. Finally, the export guarantee procedure of "Compagnie Française d'Assurance pour le Commerce Extérieur" (COFACE - French Insurance Company for Foreign Trade) facilitates the securing of advantageous trade credits by buyer countries.

All these procedures have already been employed on several occasions to finance the supply of work and equipment in the area of new and renewable energies.

In many cases, moreover, these different aid schemes have been used simultaneously. Hence FAC, CCCE (loans at 6% interest for 15 years including 8 years of deferred amortization) and COFACE are involved respectively for 15%, 32% and 33% in financing a telecommunications link in southern Madagascar, employing 19 stations operating on solar energy. This application of solar energy to telecommunications by microwave link has been made possible since French industry developed a new type of unit which consumes very little energy and can thus resort to solar energy. The "solar" portion of the system cost about 4 million French francs.

In Niger, as part of an educational television operation, FAC has financed television sets running on solar energy (1 to 2 million francs for the solar section alone).

CCCE is currently examining the possibility of granting a loan of 140 million francs on favourable terms to Gabon to double the capacities of the hydro-electric power plant located near Poubara Dam.

Treasury loans have been employed on various occasions in the new energies sector. Thus construction of the Tucurin Dam in Brazil obtained assistance in 1977 from the French Treasury amounting to 880 million francs. Similarly, in 1980, the hydro-electric installations near Machu Picchu, in Peru, were financed to the extent of 360 million francs by Treasury loans. These two operations were carried out under financial agreements concluded with the countries concerned. It is also planned to apply the Treasury loan procedure to the supply of solar pumps to Nepal, for 1 million francs. In this case, the Treasury credits are combined with guaranteed trade credits.

The latter are in widespread use and mobilize considerable sums. To quote a single example, they allowed the construction of the Djatiluhur Dam and hydro-electric complex in Indonesia (cost of the operation: nearly one thousand million francs).

4 CONTRIBUTION OF NEW AND RENEWABLE ENERGIES TO DEVELOPMENT

The experience of France, especially in the French overseas territories, can be used to predict the probable and realistic evolution of new and renewable energies in national energy balances, and shows the need for a twofold approach:

- quantitative, by substitution for traditional energies (especially for industrial uses and in the urban environment),

- qualitative, by services provided in rural development (taking account of the many problems that this poses: firewood crisis and desertification, anarchical growth of the city at the expense of the country, growing food trade deficit, threat of fresh water shortage etc).

4.1 THE NEEDS OF DEVELOPING COUNTRIES THAT NEW AND RENEWABLE ENERGIES CAN SATISFY

Traditional sources of energy can and must make their contribution to the economic growth of developing countries. However, any strategy which is based exclusively on them is liable to meet serious obstacles. Depending on the country and the extent of its energy needs, the reduction in energy dependency can be achieved by resorting to new energies (including nuclear) and renewable energies.

Their different capacities for meeting energy needs makes them far more complementary than competitive. Hydro-electric power, oil shales and geothermal energy mainly concern the urban environment, whereas solar and wind energies can facilitate rural development. The centralization of electricity, fuel and low temperature heat consumptions for industry is a characteristic of urban energy consumption, while dispersion is currently a characteristic of the energy consumption of rural development. In the absence of appropriate recourse to new energies which are not dependent upon a disproportionately expensive distribution infrastructure, present solutions are liable to marginalize the bulk of the rural populations, who only have limited access to the monetary sector, and to accentuate the firewood shortage.

It is in this context that the contribution of new and renewable energies to development must be placed. It must be considered not as a juxtaposition of technological expedients which exclude traditional technologies, but rather as one of the chief elements which allow the setting up of energy programmes adapted to the reality of the challenges posed to developing countries, such as:

- to promote more self-sufficient energy development,

- to minimize pressure on non-renewable resources,

- to satisfy the basic needs of rural populations and the poorest urban strata, in particular those needs related to food self-sufficiency,

- in the longer term, to give the developing countries an opportunity to master the technological development of a set of processes, and to implement productive but not predatory management of the biomass.

In quantitative terms, renewable energies represent today a significant share of the energy balance of many developing countries. The energies used in a traditional manner - and sometimes over-exploited or utilized inefficiently - (such as firewood, dried dung etc) account for 30 to 80% of the current balance of primary energies. To these must be added hydro-electric power which is being harnessed in many regions of the world, and the new forms of using renewable energies (biomass, wind, direct solar energy, geothermal energy etc). Together, and despite the sharp rise foreseeable in total demand, these energies can account for a significant share of the primary energy balance in the year 2000.

4.2 POTENTIALS OF THE VARIOUS TYPES OF NEW AND RENEWABLE ENERGY TO MEET THESE NEEDS

4.2.1 Hydropower

The potential of many developing countries is largely underestimated, and in many of them the mobilization of this potential can guarantee a large share of future consumption.

The huge investment outlay required for the construction of power dams, the need to create outlets for the electricity produced (e.g. electrometallurgy), and certain environmental problems, are liable to hamper the utilization of this resource. However, one must consider the secondary advantages in terms of irrigation and river navigability which must not be ignored. Furthermore, the low kWh production cost could attract energy-intensive industries to countries producing hydro-electric power, thus facilitating the financing of these operations.

Mini- and micro-hydropower plants correspond to a highly reliable technology, and provide an extremely valid solution for the electric power supply of communities located near waterways. These techniques also offer the advantage of being easily transferable. An accurate inventory of the sites is nevertheless required before planning a generalization of their use. Seasonal variations in discharge rates may also pose an obstacle to their development.

4.2.2 Sea energy

Very few favourable sites exist throughout the world for the utilization of tidal power, and their exploitation, which is technically feasible, is liable to be hampered by the large investments required.

Hopes may also be founded in ocean thermal energy conversion in the intertropical zone, where the potential is considerable. However, research into this aspect has only just begun, and the contribution of these techniques to the energy balances of tropical countries will probably only be significant around the end of the century.

Wave energy has sparked the filing of a very large number of patents, but very few of them are operational. The quest for a reliable, robust and competitive technology in the low power range is necessary.

4.2.3 Biomass

The upgrading of plant waste by gasification, the production of biogas, ethanol and methanol, has already given rise to perfectly competitive technologies. This applies to the production of biogas for heating and lighting, and to the gasification of certain agricultural wastes. Depending on the quantities provided, the gas thus produced can serve for cooking and lighting, or can drive a lean-gas motor, thus providing mechanical or electrical motive power. The methanol and ethanol processes should become competitive in the medium term. It is also important to attempt to produce a non-volatile liquid fuel for cooking (to replace paraffin).

4.2.4 Wood

The scale of wood consumption in developing countries makes it important to try to preserve its renewable character. Hence it is necessary to stop the process of desertification and degradation of the forest, and to assist reforestation. French specialists are currently trying to determine the fast-growing strains adapted to the different climates in tropical countries. This sector is vitally important for rural populations in many countries, but the effects of the activities scheduled would necessarily take a long time to be felt. In this respect, the question of massive dissemination of information appears to be especially crucial.

4.2.5 Solar energy

This dispersed and decentralized energy par excellence offers resources to all developing countries. Several uses are already competitive: solar water heaters, solar distillation units, photocells for telecommunications, signalling and village pumping.

The thermal conversion of solar energy may be on the threshold of widespread use and should give rise to local manufacture and repair operations without raising any significant technology transfer problems. Thus water heaters, distillation units and drying may come into widespread use in the coming years.

Electricity conversion by means of photocell modules may lead to a larger number of applications, and competitiveness has already been achieved for small isolated installations. The scope of application may subsequently expand with the anticipated cut in module prices: in addition to the uses already mentioned are power supply for homes (for lighting and refrigeration) and small electric power distribution networks in villages. However, photocell manufacturing technology is still evolving, which restricts the possibilities of technology transfer at the present time.

4.2.6 Wind energy

This resource is unequally distributed geographically and seasonally. The utilization of these energies along coastlines and on islands, however, is especially interesting for a wide variety of uses, as French investigations have demonstrated in several places. Windmills and wind generators can supply mechanical power directly for flour mills and water pumping. Direct conversion into electricity by wind generators makes wind energy competitive with photovoltaic solar energy, in regions which are both isolated and windswept. Local manufacture raises no difficulties. However, wind generators require more regular technical follow-up than solar photocells.

4.2.7 Geothermal energy

The world's geothermal resources are still largely unknown. However, they will be very unequally distributed and potential uses will depend on the size and characteristics of geothermal deposits. Whether for electricity generation for power supply networks, or the use of steam or medium temperature heat for industry or heating, the use of geothermal energy requires large investments but may be an alternative energy form wherever it exists and wherever energy needs are relatively high and concentrated.

4.2.8 Oil shales and tar sands

These resources, which were untouched for a very long time, may be interesting for utilization in the long term. Like other fossil fuels, the resources are still poorly identified in many developing countries, and a prospecting effort is indispensable. Simultaneously, research

into technologies for the use of these energy sources is necessary in order to achieve competitive operating costs and upgrading of the organic matter. Hence a decentralized mining of bituminous shales may be planned for the supply of liquid fuels for certain developing countries. However, despite the abundance of oil shale and tar sand resources, substitution for traditional energy forms is hard to anticipate before the end of the century in developing countries.

4.2.9 Overall summary

On the whole, and based on already proven technologies or those which may be expected to be operational in the near future, the chief uses of new and renewable energies are likely to be the following in the next two decades:

- the use of electricity provided by hydropower, geothermal energy, biomass and possibly the energy of the seas, in national distribution networks, by substitution for traditional energies,
- the supply of decentralized energy thanks to renewable energies for:
  - cooking, especially in rural areas, where it will continue to account for nearly 6% of world requirements in the year 2000, and to a lesser degree in urban areas, thanks to wood and biomass,
  - all agricultural requirements, irrigation, pastoral and village water supply, drying, storage and conversion of agricultural products (3 to 4% of world requirements), by solar or wind energy and biomass,
  - cold production by solar and wind energy in isolated communities, for the storage of fruit, vegetables and fish,
  - transportation in zones with high primary plant life productivity, in which alcohol can be substituted as a fuel for petroleum derivatives,
  - low and medium temperature applications in industry, ranging from water preheating by solar energy to the supply of steam by geothermal energy.

All these indications must naturally be weighted by the following considerations.

- New forms of utilization of renewable energies still raise the problem of a more accurate assessment of their potential, the problem of their speed of penetration and that of their competitiveness. In fact it would appear that the general opinion of scientists, who less than ten years ago considered unconventional energy forms as a necessarily marginal possibility, has changed drastically since 1973. Recent years have witnessed a grouping of research projects, making it possible to consider a substantial contribution by the year 2000 from entirely new technologies as well as from traditional fuels which have been improved.

- Many techniques for the exploitation and use of new energy forms are rapidly evolving, and it is still too early to determine exactly their level of competitiveness or complementarity, their possibilities of local manufacture, or their ease of maintenance. These aspects imply the training of national specialists and technology transfers.

- An energy programme is a decision which only exerts its full effect in terms of the transformation of energy balances over a 15 to 20 year period and which represents a commitment for several decades.

- However, a minimal contribution to the energy balance by a given process may be decisive in surmounting a specific obstacle to development. This is the case of water supply to isolated zones, and more generally of pastoral water supply. Unlike the other major alternatives (coal, nuclear), the implementation of which is essentially centralized, the impact of new and renewable energies will be increasingly felt as they render new services in isolated areas.

Any energy policy in developing countries must therefore have other goals besides energy self-sufficiency. The distinction between alternative energy for centralized networks and requirements, and auxiliary energy designed to supply isolated units, will serve to clarify the rôle and the complementarity of new and renewable energies. Finally, energy must not be considered an end in itself but a tool in the service of development. This implies the adaptation and appropriation of techniques to guarantee the integration and contribution of these new techniques to the development process.

4.3 THE CONDITIONS UNDER WHICH NEW AND RENEWABLE ENERGIES CAN REALIZE THEIR FULL POTENTIAL

4.3.1 Definition of a national policy

The concept of new and renewable energy covers several distinct aspects:

- specifically new technologies such as nuclear power, oil shales and tar sands, and coal liquefaction and gasification, which aim to replace conventional energy forms,

- already known technologies (hydropower, geothermal energy, energy of the seas) whose potential remains to be assessed accurately,

- traditional uses of biomass, which is still the chief source of energy for developing countries,

- current and forthcoming applications of solar energy, in the broad sense of the term, covering widely varying applications, ranging from the drying of agricultural produce to the production of electricity, including the distillation of brackish or salt water, pumping, and liquid fuels.

The utilization of these very different resources implies very different levels of complexity, from the simplest product within the reach of a village craftsman to the most sophisticated processes such as the automatically slaved steering of heliostats or the genetic selection of fast-growing tree strains. Furthermore, it is conceivable that several levels of complexity will co-exist for the utilization of a given set of resources or for a single process. Hence the planting of fast-growing trees requires both traditional agricultural work and the most advanced genetics for selection of the strains. Thus a solution must be found to the new problem of the integration of various solutions which call on the specific resources of each eco-region.

The variety of energy sources and their conditions of use means that each country must have an institution capable of coordinating, initiating and promoting all new and renewable energy activities, on the basis of an energy plan which accounts for all energy sources and which is well integrated into the general development plan of the country. This institution could also be responsible for the implementation of promotional activities.

The existence of such an organization will facilitate an equitable comparison with conventional energies that takes account of the following:

- the integrality of the costs of competitive energies, in particular for transport and distribution in rural zones (investments for these two items may triple production outlays); renewable energies are best valorized on the very sites of their use,

- the weighing to be made between the cost of the investments required, whether for an inventory of or the exploration of new resources or for their utilization, and the lowered operating costs frequently made possible by renewable energies,

- anticipated increases in hydrocarbon prices on the world market and the additional debt incurred by imports of crude oil, and the possible elimination of other imports of a vital nature,

- the greater divisibility of investments in most new energy processes, allowing both minimization of the risks and shortening of the repayment period.

A national organization can also prepare the necessary decision when, for example, it appears that the simplicity of the use of fuel oil or electricity dissuades investors or potential users from installing equipment utilizing renewable energies, even if their economic value is undeniable from the standpoint of the community. Deliberate political action may prove necessary to impose, for example, the use of solar collectors for hot water production.

4.3.2 Observance of natural and socio-cultural constraints

To guarantee the development of renewable energies, their penetration must also fall within a context which is acceptable to the population and which observes the major constraints of local ecosystems. They must not uproot the population but must rather confirm them in their customary environments. They must be strictly renewable, in other words they must contribute to halting the process of desertification and degradation of forests, and they must guarantee the fertility of soils and the health of livestock. They must take account of the strong bond between biomass and soil quality and integrate the rôle of animals as producers of waste and motive power. Even if it is not possible for technical reasons (lack of energy compatibility data) to model completely the energy flows related to the use of animals, it must be stressed that problems arise here which are often decisive in rural areas: problems of the integration of agriculture with livestock, of the substitution of commercial energies for animal power, or the latter for manual labour.

The success of any specific renewable energy technique will not only depend on its economic effectiveness or the respect of ecological constraints, but also on its socio-cultural integration. This is why it is important to plan technological alternatives based on the populations's expression of its needs, using the heritage and creativity of popular ecological expertise which does not necessarily exclude imported techniques when these prove essential. To avoid the failures which may greet a purely technical vision of the development of renewable energies, it is important in particular to consider thoroughly its condition of integration into the urban and rural environment, in different socio-economic and ecological systems, by making broad allowances for the incentive policies (education, training in maintenance) necessary for effective development to be achieved.

4.3.3 International cooperation

The development of new energies should not only guarantee a substantial share of the growth of energy consumption, but also contribute effectively to the regional integration of peripheral territories, to the control of the rural exodus, and to the development of the countryside.

This means that their utilization under conditions which will guarantee their success must be regarded as one of the challenges of the approaching century. To the extent that such utilization goes beyond mere proliferation or modernization of traditional practices, the industrial development of new resources, as this report attempts to show by different examples, calls for reinforced cooperation between developing countries and industrialized countries in many areas, for:

- training and the transfer of new techniques,
- adapting new techniques and existing techniques to local climatic, ecological and socio-cultural conditions,
- their assimilation and progressive integration into the native cultures of the countries concerned,
- over and above national efforts, the mobilization of adequate financial resources at all possible levels (bilateral, regional and inter-regional cooperation, efforts on the multilateral level); in this respect, the efforts currently made on the multilateral level for the development of energy resources in countries with an energy shortage should constitute an additional asset for new energies.

In this fast-changing general context, UNCNRSE must set itself the goal of gathering together all the human, material and financial resources needed for a renewal of energy sources by original methods, and must associate the entire international community in this venture.