Future Energy Sources

National Development Strategies

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ENGLISH

Volume 2
Far East and the Soviet Union

From McGraw-Hill, Publishers of
Coal Week ▪ Platt's Oilgrams ▪ Fuel Price Analysis

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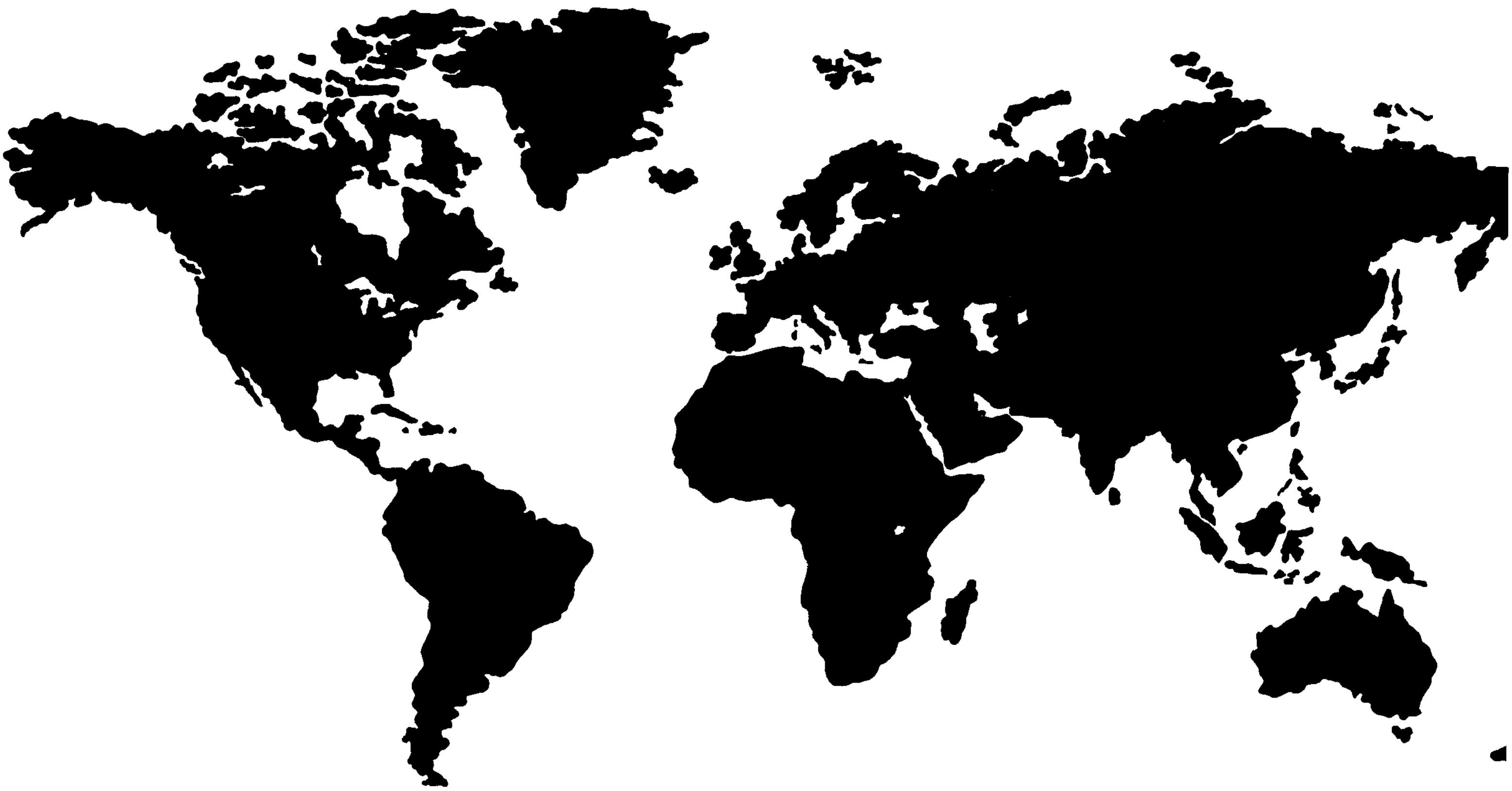

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Future Energy Sources: National Development Strategies

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Contents

JAPAN

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SRI LANKA

THAILAND

Introduction

The world has consumed more commercial energy since 1940 than in all its previous history. Energy consumption will continue to rise, but energy sources will be diversified.

The finite nature of petroleum resources, increasing demand, and soaring prices have combined to force nations to look for new and renewable energy sources that will safeguard their futures. Economic, social and industrial development, as well as national security, is at stake. For developing countries, the stakes are especially high.

How nations are attempting to reduce their dependence on oil by developing alternate sources of energy is the subject of *Future Energy Sources: National Development Strategies*. This three-volume series is a compilation of reports detailing ongoing projects and development plans for renewable resources in 29 countries. The reports are edited and abridged versions of documents prepared by national governments for the United Nations Conference on New and Renewable Sources of Energy, held August 10-21, 1981 in Nairobi, Kenya.

Renewable energy sources discussed in these reports are: solar, geothermal, wind, hydro power, biomass, fuel wood and charcoal, oil shale and tar sands, ocean energy and peat. Most country reports focus on plans for developing the more universal energy sources -- solar, hydro power, biomass and geothermal energy. However for some areas, particularly Africa and the Mideast, great attention is paid to developing wood as the projected energy base.

Although the reports vary in length and detail, most assess present energy supply and demand patterns, and outline the methods that will be used to shift to secure, indigenous and renewable sources. They describe each country's policy for the transition and pinpoint individual energy development projects underway or on the drawing board.

In creating their national documents for the U.N. conference, governments were asked by U.N. officials to specify technologies of particular interest to their country; identify major constraints to their implementation; state means of overcoming the constraints; and outline the possible scope for international cooperation.

At the conference, 89 national documents were presented. McGraw-Hill energy editors carefully reviewed the documents, selecting for inclusion in the *Future Energy Sources* series the papers containing the most specific information about energy development plans.

In editing and preparing the materials, the editors clarified language and condensed reports where it was felt these changes were appropriate. For example, strictly geographic country descriptions, and the report chapters calling for international cooperation, were deleted or condensed if they overlapped other material or were already widely known. However, the substantive meaning of the papers was in no way altered. The information in the national papers was assumed to be accurate, and was not independently verified.

It should be noted that, because the papers were prepared by the various governments, certain political tones may be apparent in some. These do not reflect the opinions of either McGraw-Hill or the United Nations.

McGraw-Hill has grouped the reports geographically into three volumes. (The U.N. document numbers of the original documents are listed at the back of this book.) The volumes and countries covered in each are:

Volume 1: Mideast and Africa

Egypt, Israel, Jordan, Kenya, Liberia, Nigeria, Pakistan, Sierra Leone, Sudan and Turkey

Volume 2: Far East and the Soviet Union

Australia, Bangladesh, China, Indonesia, Japan, Sri Lanka, Thailand and the Soviet Union

Volume 3: Western Europe and North America

Austria, Canada, Denmark, France, Ireland, Italy, the Netherlands, Norway, Sweden, the United States and West Germany

Within each volume, reports are arranged alphabetically by country. To facilitate use, the volumes are indexed by energy source and a comprehensive Table of Contents appears for each country.

The Editors

Index

Australia

CONTENTS

INTRODUCTION

At the national level, responsibility for energy policy, including energy research, development and demonstration policy, is vested in the federal minister for National Development and Energy and his department. Within his department, the National Energy Office was established in mid-1978 to meet the department's responsibilities for "national energy policy, including planning and research into coal, oil and gas, uranium, solar energy and other forms of energy."

In addition, two advisory bodies report to the minister. The National Energy Advisory Committee was established to advise on broad energy policy issues. It has published a number of reports. A report on renewable energy sources is in preparation and is expected to be published in August 1981. The National Energy Research, Development and Demonstration Council advises on the development and coordination of a national program of energy research, development and demonstration, including the allocation of grants for individual domestic projects. It also provides advice on support for international projects. The National Energy Office provides secretariat support for both the National Energy Advisory Committee and Research, Development and Demonstration Council, and is represented on both.

The executive role of the department and the advisory roles of the council and the committee are closely integrated, and there is a free flow of information between the three bodies. The National Development and Energy Department also has a range of contacts with other federal and state organizations and with industry.

Another arm of the Australian government with an interest in energy policy is the Australian Science and Technology Council. Unlike the advisory committee's relationship to the minister for National Development and Energy, this body does not report to the minister for Science and Technology, but reports directly to the prime minister. It provides an additional source of advice to the government on science and technology. It advises on the adequacy, effectiveness and overall balance of scientific and technological activities in Australia. The Development and Energy Department has observer status on the Science and Technology Council, as does the Science and Technology Council on the Energy Advisory Committee. There is a close working relationship between the two.

The federal Constitution allows for significant powers to be exercised by the Australian state governments. Thus, the six states and the Northern Territory are free to establish their own independent energy policies and energy research, development and demonstration programs. The Australian Minerals and Energy Council provides the forum for federal-state consultation at the ministerial level on major energy issues, including energy research, development and demonstration. The minister for National Development and Energy represents the federal government in discussions on energy.

Australia has joined the International Energy Administration's Energy Systems Analysis Project, which seeks to assess the potential contribution of new energy technologies in the future and to develop the research, development and demonstration strategies that will be required to bring about these technologies. The Development and Energy Department serves as the operating agent for this project, while the Australian Atomic Energy Commission, a statutory body of the Australian Parliament that reports to the minister for National Development and Energy, acts as the designated agency.

There is no all-embracing scheme under which Australian energy research, development and demonstration are funded. However, the federally financed National Energy Research, Development and Demonstration Council provides a significant component of the total funding and is directed to meet national policy objectives. These funds are available to all sectors performing energy research, development and demonstration including federal and state government organizations, tertiary educational establishments and private individuals. The state governments also develop and fund their own programs, according to their own state and regional policies. Similarly, industry undertakes energy research, development and demonstration, utilizing its own funds. The tertiary educational sector also carries out energy-related work and supplies basic facilities, staff and support.

From 1978-1979 to 1980-1981, the three years of operation of the National Energy Research, Development and Demonstration Council Program, total commitments under the program were $(Aust) 58.4 million. However, this allocation is superimposed on the existing activity, and, as a result, has the effect of modifying the overall balance of energy research, development and demonstration and directing it more toward national energy objectives.

It is recognized that the simplest way to commercialize energy research, development and demonstration results is to have the original work performed by industry. Indeed the percentage of total National Energy Research, Development and Demonstration Council Program grants to private industry has increased from 31 percent in 1978-1979 to 49.5 percent in 1980-1981. In assessing proposals from non-industrial applicants, the council takes into account interest shown by Australian industry to date.

Funds for energy research, development and demonstration projects in industry also are provided by the Australian Industrial Research and Development Incentives Board. Up to 50 percent of the total project cost may be provided as a grant. In addition to projects selected for support as a result of publicly invited applications, the board, in collaboration with the Department of Science and Technology, arranges for projects to be undertaken in the public interest. Such projects are particularly directed toward the commercial development by industry, of important Australian innovations which would not proceed without significant government support.

Small to medium demonstration projects are currently being supported under the National Energy Research, Development and Demonstration Program. The terms of reference of the council include provision to advise the minister of the desirability of making a submission to the government for special additional funding in the case of major demonstration projects aimed at assessing the feasibility of new technologies. Demonstration projects aimed primarily at commercialization are mainly the responsibility of private enterprise. The Australian government considers that its key task is to ensure that the basic economic climate is conducive to long-term investment by private enterprise in new technologies.

Assessment of the Need for Different Forms of Energy

Australia has well-developed systems of energy statistics collection and analysis which aid the energy planning process. Both the federal government and states are engaged in analysis of present demand and prediction of future trends in their respective areas of responsibility, and the results of their analyses play an essential part in their policy formulating and planning activities.

The National Development and Energy Department regularly publishes reports indicating historical and future trends in energy demand by fuel type and major end-use sectors.

The latest report on historical fuel use, titled "Demand for Primary and Secondary Fuels in Australia: 1960-1961 to 1979-1980," was published in February 1981. The data contained in this report is based primarily on the results from a fuel survey of the mining, manufacturing, electricity and natural gas supply industries. Data collected also includes information on the fuel equipment devices and process temperatures used in these industries, which will be useful in evaluating the potential impact of new and renewable energy sources in these industries.

The data collected from the fuel survey is complemented by other less detailed statistical collections for the other sectors. Data is not available, however, for energy use in the domestic sector dissected by end-use purpose (such as cooking, lighting and heating).

The data for energy demand is combined with information on energy supplies and published in an energy balance format (both tabular and as a flow chart) for coal, oil, natural gas and electricity, and the renewable sources: wood, bagasse and hydroelectricity.

The department also prepares and publishes projections of future energy demand and supply. The next report containing these projections is expected to be published in May 1981.

Price data for electricity and natural gas is available in the form of average revenues paid and as published tariff rates for various end-users for all states. Maximum justified wholesale petroleum product prices are set and published by the Prices Justification Tribunal.

Assessment of Available New and Renewable Sources

Australia has long been aware of the need for accurate assessments of its energy resources. The Bureau of Mineral Resources was established in 1946 to study geological and geophysical information, and carry out a wide range of geoscientific reasearch to form a basis for expanded exploration activity and improved assessment of Australia's mineral and petroleum resources. The bureau is now a part of the energy and development department.

The task of resource assessment in Australia has been greatly assisted through the availability of accurate maps, prepared by the Department of National Development and Energy's Division of National Mapping.

As one of its first tasks, the National Energy Advisory Council, during 1977, prepared a report summarizing Australia's renewable and non-renewable energy resources. The report also included an assessment of the adequacy of the information on energy resources available for decision making at the national level in the field of energy policy. An updated version of this report is expected to be released in mid-1981.

In its first report on energy resources in Australia, the council considered that there were still some major areas where information was inadequate for effective analysis of Australia's renewable and non-renewable energy resources, and that for most forms of energy considerable additional exploration, research and assessment was required to achieve a desirable level of knowledge.

This situation has improved markedly since the release of the first report. The Commonwealth Scientific and Industrial Research Organization is a statutory body responsible to the Minister for Science and Technology. As a part of its ongoing research activity into new and renewable sources of energy, the organization recently released reports on the potential for liquid fuels from agriculture and forestry in Australia, and the potential of oilseeds as a renewable source of diesel fuel.

In addition, the Bureau of Agricultural Economics, part of the Department of Primary Industry, has undertaken research into the economics of the production of fuels from agricultural products.

The commonwealth government, through the National Energy Research, Development and Demonstration Council, has funded resource assessment studies such as the determination of the extent of Australia's oil shale deposits, estimation of the potential productivity of cassava for ethanol production, and wind energy availability and potential in Bass Strait.

Sectoral Priorities

Most populated areas of Australia are already well supplied with energy from conventional sources. Electricity is widely distributed in each state through grid systems, natural gas pipelines are being extended in a number of areas, and a widespread petroleum products distribution network has been in place for many years. As a result of the ready availability of these sources of energy, planning focuses on meeting the overall levels of demand where it is economic to do so, rather than specific sectoral requirements. Special account would, of course, be taken of large projects within a particular sector, such as aluminum smelters or shale oil development, which might place special demands on energy supply systems.

Alternative liquid fuels offer one important means of meeting Australia's liquid fuel needs, as Australia's own reserves of conventional oil are depleted in the future. Large-scale projects to provide liquid fuel from alternative sources, such as the Rundle and Julia Creek oil shale projects, are therefore being encouraged through oil pricing and other policies.

Populations in remote areas of Australia are usually dependent on petroleum products for all their energy needs. Transport costs to these remote locations greatly increase the economic costs of the fuel, and hence these areas could benefit greatly from utilization of renewable energy sources such as wind or solar energy. The government recognizes the needs of these areas in the distribution of research, development and demonstration funding through the National Energy Research, Development and Demonstration Program.

NEW AND RENEWABLE ENERGY SOURCES

As described, the National Energy Office is responsible for national energy policy including energy research, development and demonstration policy.

It gathers statistics and carries out energy forecasting and modeling studies as well as energy surveys, and provides considerable information on energy in published and unpublished forms, ranging from pamphlets to major statistical compilations and research reports.

The state governments are also active in the field of energy and have departments and advisory bodies responsible to state ministers for energy. In addition, most states own and operate public utilities, which support energy research, development and demonstration in their own areas of interest.

The Australian Atomic Energy Commission, a statutory body reporting to the Minister for National Development and Energy, together with the Commonwealth Scientific and Industrial Research Organization and the Bureau of Mineral Resources, are the three major performers of energy research, development and demonstration at the federal level. Each of these organizations funds and develops its own core programs of energy research, development and demonstration, most of which are undertaken in-house.

In addition to the performance of research in-house by private enterprises, a number of research associations, which are cooperative ventures, undertake research and development on behalf of groups of companies of like interest. These research associations also are involved in information transfer to the industry they serve. For example, the Sugar Research Institute undertakes research into sugar cane harvesting, transport and processing on behalf of sugar mills in Queensland. Some of this research is related to biomass energy.

Australian universities and other tertiary institutions also make an important contribution to research into new and renewable forms of energy.

The Standards Association of Australia, an independent non-government body, has established a Technical Committee on Energy Auditing with the object of devising standards and guidelines as aids to energy management. It is currently working to produce standards for the thermal performance of buildings and efficiency standards for appliances, equipment and building management. State governments are expected to require the labeling of major household appliances once these standards have been set.

New and renewable energy resources currently contribute some 8 percent of Australia's primary energy supplies. Most of this is from hydroelectricity, but there is a small and growing component of renewable resources using newer technologies. Shale oil is expected to contribute to Australia's liquid fuel supplies by the end of the century.

Oil Shale

Australia has substantial oil shale resources. Some deposits have been utilized periodically for oil production, such as the deposit at Glen Davis in New South Wales, but most interest now is centered on the major deposits in Queensland, at Rundle, Julia Creek, Nagoorin, Yaamba, Duaringa and Condor.

Solar

Household Water Heating: There are at present about 80,000 household solar hot water systems operating in Australia, mainly in the north and west of the country, where climate and electricity tariffs provide the most suitable conditions. This represents 3 percent of the potential national market. Substantial penetration of the largest markets in the southeast of the country cannot be expected until system prices drop or the price of electricity and gas rises, or both.

Industrial and Agricultural Uses: Apart from long-standing applications such as salt production, there is no significant use of solar energy in agriculture and industry at present. This will require higher fuel prices and lower cost equipment operating at temperatures below 100°C and the development of a new generation of low-cost collectors which can generate heat at 100°C and above. Research and development is currently proceeding on a range of advanced flat plate, vacuum tube, and concentrating collector designs and one, the Vulcan, is now being marketed. Industrial demonstration installations in the food processing industry are either in place or being planned in all states.

Research into some agricultural applications such as heating of greenhouse and crop drying has yielded promising results. These applications could well be economical in the near term.

Heating and Cooling of Buildings: There are about 30 houses documented in Australia which have been designed specifically to capture and utilize solar energy with passive features such as house orientation, shading and thermal mass. Computer models have been developed to assist the design of such houses, and a number of experiments to determine the effectiveness of these features are underway. There are a few examples of "thermal design" in commercial and industrial buildings in Australia, but much experimental work still needs to be done to determine which measures are most appropriate for particular climates. Nevertheless, it is already apparent that passive features in both commercial and domestic buildings can yield an economic rate of return at current energy prices.

A number of buildings with either active heating or cooling systems (those which incorporate specialized machinery to capture and utilize solar energy) are being evaluated. Research on conventional and solar-boosted heat pump systems also is being carried out.

Photovoltaics: Currently, photovoltaic arrays are installed and are providing power for isolated communications installations and other specialized uses, although they are not economical (at about $12 per peak watt) for widespread use. As array costs drop, they probably will find much wider application in remote areas.

Solar Thermal Electricity Generation: Solar thermal electricity generation systems will be installed at White Cliffs, New South Wales, and Meekatharra W.A. Studies of the feasibility of a 1 MW plant at several sites in northern Australia indicate that this technology may only be viable in the long term, when new developments might bring system costs down.

Biomass

Australia's primary interest in biomass is as a source of alternative liquid fuels. Technology for the production of ethanol from such feedstocks as sugar cane is already well known, although research into novel feedstocks and the improvement of present technology are underway. The only current commercial use of ethanol as a transport fuel is in a marketing trial for an ethanol blend underway in the Queensland town of Mackay.

The potential of vegetable oils to act as an extender or replacement for distillate is being assessed by way of a program looking at agronomy of possible crops, harvesting, extraction and treatment of the oils and their suitability in diesel engines.

Wind

Wind-powered water pumps have been a feature of rural Australia for many years. Interest in electricity generating systems in the 5 to 10 KW range for remote area applications has been rekindled in recent years following the oil crisis. Research and development is focusing on some novel designs, such as a hybrid solar/wind power development by Dunlite. There is no research and development into large-scale wind systems in Australia, although some state electricity authorities are considering medium- to large-scale systems for some remote, windy sites.

Hydro Power

Hydro resources currently contribute some 5 percent to Australia's primary energy needs, but this is not expected to increase significantly in the future, as most suitable sites have been developed.

Fuel Wood and Bagasse

About 3 percent of Australia's primary energy requirements are provided by fuel wood (1 percent) and fibrous sugar cane waste (bagasse) (2 percent). Bagasse is exclusively consumed in sugar mills, where it is used to raise steam for process heat and electricity generation; excess electricity is often fed back into the local grid. Fuel wood is used in domestic and minor commercial applications. It is expected that the contribution from these energy sources will remain constant in absolute terms.

Energy from the Ocean

The use of tidal energy to generate electricity has been investigated and it appears that the most suitable sites are in the northwest of the continent where tidal movements are large. Development costs are still too high to be considered economic, and in any case the suitable sites are far removed from any substantial electricity market.

Research, Development and Demonstration Infrastructure

Australia has a relatively sophisticated research and industrial infrastructure, which generally does not impose constraints on the development and deployment of new and renewable energy technologies, although much technology will be imported. In the more remote areas the lack of a nearby technical infrastructure does place a premium on technologies which require little or relatively unsophisticated maintenance.

Constraints

The Australian government is in favor of the development of new and renewable energy resources, but not at any price. Protection of the environment is an important national and regional consideration, and as a consequence large-scale projects must satisfy both federal and state laws relating to impact on their surroundings. Before commencement of any project, developers are required to prepare an environmental impact statement which details the extent of air and water pollution, resource and manpower requirements, and social and cultural impact of the project, and demonstrate that the project will meet the legislated environmental standards.

Compared with other countries, there are few social attitudes constraining the development or increased utilization of energy from new and renewable sources. Social attitudes have, however, had an impact on the development of hydroelectricity in the state of Tasmania, where further development has been widely questioned on the grounds that it will destroy river valley wilderness areas in the state. The issue is still the subject of considerable debate within the Australian community. The use of food crops for the production of ethanol could become an issue of debate, if large-scale ethanol production were ever envisaged in Australia.

The major obstacle to the greater use of new and renewable sources of energy is their high capital cost relative to the alternatives of coal, oil, gas and electricity. Market penetration will increase as research and development and mass production techniques bring costs down, and as the price of oil increases.

In areas such as the passive design of buildings to improve thermal performance, a major constraint is the dissemination of design information to building users and designers. This will require a major effort to overcome.

Control of effluents and adequate rehabilitation of mined land are problems common to all mining and processing ventures. In the case of the very large-scale synfuels technologies, such as oil from shale, the potential hazards are correspondingly larger and not always known. Adequate control will require ongoing research and monitoring efforts.

NATIONAL POLICY FOR NEW AND RENEWABLE SOURCES

The overall direction of Australia's energy policy is determined by the fact that Australia is well endowed with most energy resources except conventional oil. Its broad thrust is two-fold:

- Achievement of the maximum practicable self-sufficiency in liquid fuels (taking into account appropriate economic considerations).

- Realization of the industrial development and related export opportunities open to Australia as a country rich in energy resources.

The most immediate issues relate to the need to secure Australia's supplies of liquid fuels. The Australian government has introduced a number of measures to accomplish this. These measures will:

- Encourage conservation of scarce sources of energy -- in particular liquid fuels.

- Promote the use of locally available alternatives to oil -- particularly natural gas, LPG and coal-based electricity.

- Stimulate commercial development of major new energy projects in areas such as shale oil, coal liquefaction and ethanol.

- Provide a major incentive to increase oil exploration activity and maximize development of existing fields.

Fundamental to achieving these objectives has been the use of market forces, through the realistic pricing of petroleum products. This measure alone will do much to encourage consumers to adjust their energy use patterns and promote the production of alternative and conventional forms of energy.

To further encourage these changes in energy consumption patterns, the government has organized national energy conservation programs aimed at motor vehicle users, and industry. These measures have been supplemented by the introduction of a number of incentives to encourage consumers to switch away from oil to alternatives such as natural gas, coal, solar or biomass. These include:

- Removal of sales tax from all solar appliances, from non-oil-fired domestic space heating appliances and from kits for converting motor vehicles to LPG or CNG.

- A tax incentive whereby, when oil-fired equipment is replaced by equipment powered by other fuels, 40 percent of the cost of the replacement plant is deductible in the year in which the plant is first used or when oil-fired equipment is converted or adapted for other fuels. The capital costs are allowed as an outright deduction in the year in which the costs are incurred.

- Exemption of fuel ethanol for excise and a licensing scheme to permit working trials of small-scale fuel ethanol production, particularly in the rural sector.

The need for research and development to improve the utilization of energy resources, both non-renewable and renewable, is recognized by the government, and assisted at the federal level through the National Energy Research Development and Demonstration Program. Funding for projects is distributed in accordance with priorities which stem from the broad objectives discussed above.

In view of Australia's rich endowment of depletable energy resources, it is not expected that renewable sources of energy will make a major contribution to Autralia's energy before the end of the century. The government's aim is to ensure that the resources available for the development of all energy sources within the country will be utilized in the most efficient manner, through the application of market forces. No particular energy source, therefore, has a rigidly designated role in Australia's energy future.

It is recognized, however, that new and renewable sources of energy have the potential to make a significant contribution to Australia's future energy needs, and Australia's energy strategy therefore includes the provision of funds for research and development of these energy sources.

RESEARCH, DEVELOPMENT AND DEMONSTRATION ORGANIZATIONS

Commonwealth Government

(a) Australian Atomic Energy Commission

- Hydrogen production by solar-assisted electrolysis of water.

- IEA Energy Technology Systems Analysis program (Australian designated agency for this program).

- Feasibility study of a solar thermal power plant.

(b) Bureau of Mineral Resources, Geology and Geophysics

- Geothermal studies of the heat flow region in various tectonic provinces in Australia.

- Studies of marine oil shale deposits.

- Assessment of oil shale in the Toolebuc formation (joint project with CSIRO).

(c) Commonwealth Scientific and Industrial Research Organization

Within the CSIRO Energy Program, there are several research programs concerned with new and renewable sources of energy. These are:

- Oil shale exploration and characterization.

- Coal conversion.

- Organic chemistry of fuels and metals.

- Agro-industrial assessment.

- Biotechnology.

- Solar energy research.

- Assessment of renewable energy sources.

- Wind energy.

- Energy storage.

Within these programs the following projects are of particular interest:

- Biosynthetic production of fuels from lignocellulose.

- Development of flat-plate collectors for use up to 150°C.

- Industrial solar water heating (joint project with SERIWA and Solokool Drinks).

- Integration of wind power on a large scale into state electricity grids with short-term storage.

- Oil shale: assessment of properties and regional controls.

- Photovoltaics and photoelectrochemistry.

- Ion-beam deposited thin film coatings for solar energy devices.

- Solar space heating system for low energy consumption house.

- IEA solar research and development Tasks III -- performance testing of solar collectors.

- Development of solar heat generating systems suitable for large-scale use in Australia. Systems include a soft drink factory, solar space cooling project suitable for Australia's hot, humid conditions, and development of low energy greenhouses.

- Solar industrial demonstration program technology transfer.

- Solar photolysis of water.

- Preparation of low reflectance films on cover plates used in solar collectors.

- Transparent conducting films for MIS solar cells (joint project with University of New South Wales).

- Assessment of the potential for wind power applications in Australia.

- Wind monitoring and analysis of data.

- Catalytic upgrading of Australian shale oils.

- Nuclear geophysical techniques in oil shale industry.

(d) Telecom Australia

- Testing, evaluation and demonstration of solar cell array.

(e) Bureau of Agricultural Economics

- The economics of alternative fuels from agricultural products.

State Governments

(a) Energy Authority of New South Wales

- Forbes Abattoir solar energy installation (proposed joint project with CSIRO and Norwest Beef Industries Ltd.).

- Passive solar energy housing for Sydney growth areas (joint project with University of New South Wales and Housing Commission of New South Wales).

- Solar appliance testing (joint project with the University of New South Wales).

(b) Gas and Fuel Corporation of Victoria

- Evaluation of solar collectors in the 100°C to 300°C temperature range.

(c) Health Commission of New South Wales

- Assessment of performance of solar air conditioning installation at Jerilderie hospital.

(d) Hydroelectric Commission (Tasmania)

- Bass Strait wind energy study.

(e) New South Wales Department of Agriculture

- Enzyme hydrolysis of insoluble polysaccharides.
- Experimental and economic evaluation of farm-scale ethanol production.
- Utilization of vegetable oil as a distillate replacement.

(f) Northern Territory Department of Mines and Energy

- Small-scale application of solar energy in remote areas in substitution for fuel-generated power.

(g) Solar Energy Research Institute of Western Australia

- Industrial solar water heating.
- Solar air conditioning using evacuated tube collectors (joint project with Yanchep Sun City Pty. Ltd.).
- Solar housing construction and monitoring program (joint project with State Housing Commission of Western Australia).
- Solar housing competition: performance analysis of winning designs.
- Radiation, temperature and wind monitoring network.
- Solar steam generation for industrial applications -- demonstration project.

(h) State Energy Commission of Western Australia

- Controlled tests of vegetable oil fuel for compression ignition engines.

- Investigation of alternative transport fuels including hydrated ethanol and ethanol/petrol blends.

- Remote area power supply investigation involving solar thermal generation, wind generators and systems modeling.

(i) Western Australian Department of Agriculture

- Minimum tillage research.

- Small-scale aqueous processing of oilseeds for fuel oil and improved meal production.

(j) Victorian Solar Energy Research Committee

- Demonstration of solar water heating in the meat processing industry, for swimming pools and milk pasteurization.

- Warrnambool wool scour: demonstration of solar water heating.

- Demonstration of passive and active building heating systems.

- Demonstration of solar boosted heat-pump systems.

(k) South Australian Department of Mines and Energy

- Industrial solar water heating (joint project with CSIRO and Southern Farmers Ltd.).

Private Enterprise

(a) APACE Research Ltd.

- Ethanol-distillate emulsified blends in diesel engines.

- Recovery of ethanol from ethanol-water mixtures.

(b) Australian Cassava Products Pty. Ltd.

- Agronomical research of cassava for power alcohol.

(c) Biotechnology Australia Pty. Ltd.

- Pilot-scale continuous ethanol fermentation.

(d) Broken Hill Proprietary Co. Ltd.

- Design of a 50 cubic meter per day solar desalination plant.

(e) Bureau of Sugar Experiment Stations

- Sugar cane biomass.
- Waste treatment in an "ethanol from sugar cane" plant.

(f) CSR Ltd

- Cassava agronomy.
- Conversion of Julia Creek shale oil into automotive fuels.
- Ethanol from cassava for transport fuel by batch fermentation.
- Improved yeast technology for ethanol production.
- Julia Creek oil shale retorting.
- Treatment of waste water from alcohol production from cassava.
- Enhanced extension of petrol with aqueous alcohol.

(g) S.W. Hart and Co. Pty. Ltd.

- Development of a new low-cost, high-efficiency solar collector using a chrome black surface.
- Chrome black treatment bath plant.

(h) Millaquin Sugar Co. Pty. Ltd.

- Evaporation and incineration of ethanol distillery effluent.

(i) National Iron and Steel Pty. Ltd.

- Industrial solar air conditioning using concentrating collectors (joint project with University of Western Australia).

(j) Queensland Cane Growers' Council

- An economic assessment of the integration of sugar and ethanol production in Australia.

(k) Repco Ltd.

- Evaluation of ethanol use in vehicles.

(l) Siddons Industries Ltd.

- Development of solar-boosted heat pumps.

- Commercialization of mild steel flooded passage flat plate collector.

(m) Solarex Pty. Ltd.

- Development of low concentration solar power supply using a novel tracking system.

(n) Sugar Research Institute

- Biological treatment of effluent from distilleries fermenting cane juice and molasses.

- Use of bagasse as a fuel in boilers instead of fuel oil (joint project with University of Queensland).

(o) Tideland Energy Pty. Ltd.

- Development of solar photovoltaic cells and manufacturing methods including improved module encapsulation techniques.

(p) Vulcan Australia Ltd.

- Development of a self-tracking parabolic trough concentrating solar collector.

Tertiary Education

(a) Australian National University

- Design and construction of a 25 KWe solar thermal power station.

- Demonstration and performance testing of a parabolic dish solar collector.

- Demonstration of a laboratory-scale chemical (ammonia) heat pipe.

- An energy model for Australia.

- Hydrogen formation by photosynthetic processes.

(b) Flinders University of South Australia

- Conversion of direct solar energy: high temperature (130°C to 180°C) concentrating collector system.

- Vertical axis wind turbine.

(c) James Cook University of North Queensland

- Analysis of agriculturally produced oils for diesel engine fuels (jointly with the University of South Pacific, Fiji).
- An integrated energy/environment systems model for Australia: an operational policy design tool.
- Facilitation of the breakdown of waste lignocellulosics.
- Investigation into microstructural and optical properties of solar collector materials under various environmental conditions.
- A solar ice plant.
- A study of solar air conditioning and refrigeration systems.

(d) Macquarie University

- Solar energy utilization through chemical processes at catalyst surface.

(e) Monash University

- Mirror augmentation for high temperature flat plate solar collectors.
- Solar collector testing facilities.
- Solar transmittance of honeycombs, slats and vee corrugated covers for high temperature flat plate solar collectors.
- Use of rotary regenerative heat exchangers for conservation of energy in buildings and for air conditioning systems utilizing waste or solar heat.

(f) Murdoch University

- Development of a new solar cell using metal sulfide films.
- Production of ethanol from wastepaper and crop residues.

(g) Tasmanian College of Advanced Education

- Seasonal performance of heat pumps.
- Two demonstration houses with passive solar heating utilizing a modified Trombe-Nichel wall in Tasmania.

(h) University of Melbourne

- Demonstration of solar-boosted heat pump systems.
- Development of an air-cooled solar absorption cycle plant.
- Energy conservation techniques and solar energy applications in agriculture.
- The potential for use of refuse-derived fuels in Australia.
- Power ethanol production.
- Using a liquid to collect and store solar energy in greenhouses.
- Passive solar demonstration houses: direct gain and trombe wall.
- Use of hydrogen as an engine fuel for vehicle use.
- Use of solar ponds for salt production.
- Use of stationary spherical concentrating solar collecting for process heat (500°C) and power production.

(i) University of Newcastle

- Automated testing of solar panels.
- The swimming pool as a solar absorber/energy store for heating/cooling houses by heat pump.

(j) University of New South Wales

- Bioconversion of cellulosic materials to ethanol.
- Conversion of solar energy to electricity using electrolytic films.
- Pilot-scale development of Zymomonas process for ethanol fermentation.
- Development of low-cost MIS silicon solar cells.
- Long-term performance of solar collectors.
- Modeling of anaerobic digesters for the production of methane.
- New technology for fermentation ethanol from agricultural materials.

- Non-focusing solar concentrators for solar energy utilization.

- Non-tracking concentrators: solar thermal and solar electric.

- Performance of solar water heaters.

- Photoconducting polymers in solar energy and imaging processes.

- Photovoltaic collector technology: refracting concentrators.

- Silicon solar cells with integrated bypass diode.

- Solar appliance testing.

- Solar drying of primary produce.

- Solar electricity (using MIS solar cells) for remote rural holdings.

- Solid state transport: application in the field of solar energy conversion and storage.

- Stationary solar concentrators.

- Thermoelectric generator using a non-focusing solar concentrator.

- Characteristics of thermo-syphon flow in solar collectors.

(k) University of Queensland

- Estimation of cassava productivity for potential alcohol production in northern Australia.

- Ethanol production by continuous stirred tank fermentation: design operation and waste treatment.

- Evaluation of a concentrating collector for solar domestic water heating.

- Evaluation of a 5 to 10 KWe solar thermal electric generator.

- Fundamental studies in enzymatic biomass conversion.

- Improvement of the microbial process and development of new fermentation technology for the production of ethanol from sugar using Zymomonas mobilis.

- Induced junction silicon photovoltaic solar cells.
- Latent heat storage of solar energy systems.
- Passive cooling/heating: variable emittance roof.
- Photovoltaic cells using electrodeposited semiconductor films.
- Solar power supply for remote rural consumers.
- Monitoring of prototype solar pond for electricity generation.

(l) University of Sydney

- Concentrating collector (evacuated tube) test facility.
- Production of ethanol from cassava for use as a petrol substitute or extender: continuous tower fermentation.
- Solar assisted water/lithium bromide air conditioning system.
- Solar simulator for testing non-focusing solar collectors under reproducible conditions.
- Solar thermal electric generation (1 to 3 KWe) with medium temperatures.
- Tubular glass evacuated solar collectors.
- Ammonia/water absorption cycle in the active cooling of buildings.

(m) University of Tasmania

- Review of possible uses of wood wastes.

(n) University of Western Australia

- Development of a high-temperature stable black chrome selective surface.
- Low-cost concentrating photovoltaic system for remote power supply.
- Low-cost concentrating solar collectors for industrial and mineral processing applications.
- System connected with wind power generation.
- Wheatlands grain ethanol production and use.

(o) University of Wollongong

- Low-rank oil shales (joint project with the University of Newcastle).

(p) Western Australian Institute of Technology

- Solar thermal energy storage by phase change materials.

RESEARCH, DEVELOPMENT AND DEMONSTRATION PRIORITIES

High Priority

- Conservation of liquid fuels including increased efficiency in all uses.
- Technology of exploration, assessment and recovery of oil, oil shale and gas.
- Development of liquid fuel alternatives to petroleum for transport such as methanol, oil from shale, oil from coal, ethanol and vegetable oils and plant hydrocarbons.
- Substitution of other fuels and energy sources for petroleum-based fuels by conversion of oil-fired installations to coal-fired and use of solar energy in industry and for space heating and cooling.
- Improvement in the exploration, assessment and production of coal.
- Improvement in coal combustion technologies, including emission control.
- Economic and social effects of changes in the pattern of energy supply and demand.
- Environmental effects of increased coal and shale mining and their conversion to synthetic liquid fuels.

Medium Priority

- Uranium exploration, mining and enrichment.
- Environmental effects of increased uranium mining and enrichment, including waste management.
- Coal gasification including in situ production.
- Development of efficient long-range electric vehicles and batteries.
- Remote area applications of solar energy -- both thermal and photovoltaic.

Low Priority

- Nuclear fusion.
- Magneto-hydrodynamics.
- Nuclear power generation.
- Use of hydrogen as a fuel.
- Pyrolysis of wastes to produce liquid and gaseous fuels.
- Large-scale wind energy systems.
- Wave, tidal, ocean thermal and geothermal energy systems.

Bangladesh

CONTENTS

INTRODUCTION

Bangladesh is a flat deltaic region washed by some of the mightiest rivers of the world. The total surface area is about 55,598 square miles (143,998 square kilometers) and is inhabited by about 90 million people, making it one of the most densely populated areas of the world. Per capita land availability is only .38 acres, while the cultivable land per head is even less than .27 acres. The urban population hardly being 10 percent of the total population, Bangladesh is like a big, continuous village. Average sunshine is more than 200 days per year. Location and topography make Bangladesh a natural potential source of solar, biomass and other forms of new and renewable energy.

Bangladesh is basically a country of traditional agriculture, following age-old methods and using little commercial energy. The economy derives about 54 percent of its GDP from agriculture. Other components are about 12.3 percent from large and small industries; 10.8 percent from trade; about 6 percent each from transportation and communication, housing and other services; 2.45 percent from public administration and 1 percent from banking and insurance.

Although more than half of the GDP is attributable to agriculture, only 12 percent of the total cultivable land is under modern agricultural practices of irrigation, drainage, HYV seeds, chemical fertilizer and other inputs. But as the strategy for future development is geared to modernizing agriculture and increasing its productivity and yield, the need for energy for agricultural development is going to increase substantially.

The per capita commercial energy consumption of 48 kilograms of coal equivalent per year in Bangladesh is one of the lowest in the world, whereas commercial energy -- oil, natural gas, coal and hydroelectricity -- accounts for roughly one-third of the total energy consumption.

Virtually all petroleum, petroleum products and coal are imported, but natural gas is indigenous. Expressed in coal-equivalent terms, the total use of commercial energy in Bangladesh was nearly 4 million tons of coal equivalent in 1979-1980. Of this, the contribution of oil and oil products was 53 percent, gas 37 percent and coal and hydroelectricity contributed about 5 percent each.

Bangladesh uses about 1.6 million tons of petroleum and petroleum products per year, all of which is imported. Although the trend is toward increase, the government is taking steps to contain consumption. There is a refinery of 1.5 million tons nominal capacity, now handling a throughput of about 1.2 million tons per year. Its output product mix does not match the market demand, hence a part of the mid-distillate requirement including kerosene and diesel has to be imported as finished products. The cost of the import of oil affects the balance of payments of the country greatly. In gross terms, it is claiming nearly two-thirds of the total export earnings. However, some surplus products after refining also are exported, which eases the situation slightly. Use of natural gas saves about $220 million equivalent of foreign exchange at the current level of consumption, and although there is plenty of gas resource, constraints hinder its use to replace oil.

Full geological or geophysical investigations for the whole country will take a long time to complete. Hence, no specific upper limit for energy and mineral resources can be assigned yet. It is proven that the eastern part of Bangladesh is a good natural gas prospecting zone, where the reserve is estimated at about 11 trillion cubic feet. Final reserves may be much larger -- for a country of about 56,000 square miles, only about 60 wells have been drilled so far. However, the proven gas reserve, although small (according to international standards), is ample for the country's needs for quite some time. No gas has yet been discovered in the western part of the country, but there is coal there, the reserve of which has been placed between 1 billion and 1.5 billion tons. Although search is going on, no oil has been found yet. There is a deposit of some 133 million tons of peat. Being a flat deltaic region, hydro-potential of the country is very limited. The present estimate puts the resource at 1,300 MW, of which only 130 MW has been harnessed so far. However, the prospects of significant increase of hydro-potential exploitation are limited due to many reasons.

Having a subsistence economy, Bangladesh has been using renewable sources of energy employing primitive technologies from time immemorial.

Even now, nearly two-thirds of her total energy needs are estimated to be met by such sources as cow dung, rice husks, crop residues, vegetable wastes, firewood and the like. Being situated in a hot, humid region, and the landmass being crossed by innumerable rivers and streams, the region is ideal for fast growth of biomass.

Considering its topography, geographical location, climatic condition and resource endowment, the following sources have been considered for Bangladesh: solar, biomass, peat, wind, mini-hydro, geothermal and ocean.

SOLAR ENERGY

Owing to the location in the tropics, solar energy plays a prominent role in the energy balance of the country. Use of solar energy in drying of jute, grains, fish, vegetables, tobacco, production of salt from sea water, making of bricks and pottery, and other diverse uses is very common. A theoretical estimate of the total radiation falling on Bangladesh has been placed at above 700 to 900 X 10^{15}KJ per year. A fraction of a percent of this energy is more than the total commercial energy use of Bangladesh at the present time.

It is believed that solar energy, through appropriate technology, can be of great benefit to the rural population. Solar energy can be used through thermal or photovoltaic processes.

In the thermal process, application of solar energy can be made for improvement of the traditional drying process for fish, crops and grains, and also for running refrigerators of high thermal efficiency in the rural areas, and some low-temperature heat systems for industries. Solar thermal power systems have potential in water pumping for irrigation, and also for motive power for rural small industries. Solar photovoltaic has potential use in operating radios, televisions, freezers and lighting in rural areas. However, the largest use of solar conversion in the context of Bangladesh, is, of course, in energy farming using high-efficiency photosynthesis by trees, plants and other fast-growing algae.

There are bright prospects for using solar energy in the following fields:

Direct Thermal Application

- Drying.
- Hot water for domestic and industrial use.
- Solar cooling and refrigeration.
- Desalinization of water and brackish water.
- Domestic cooking.

Solar Cells

- Radio, television.
- Refrigeration.
- Other uses.

Solar Dryers

Tent-type dryers, consisting of polythene sheeting on a bamboo frame, have been fabricated and tested for drying fish, vegetables, fruits and spices. The dryer proved successful in killing fly larvae and adult flies. An improvement of drying time of 25 percent is possible. Hot boxes and cabinet type dryers also are being developed to dry paddy and chillies during the monsoon.

Solar Stills

Basin-type solar distillation stills, with a 3.5 percent brine solution and brackish water, have been studied to find the effect of liquid depth, liquid and glass temperature difference and liquid and ambient temperature difference on the productivity. Solar earth-water stills also have been fabricated and tested for the production of drinking water during the dry winter season.

Solar Water Pumping

A miniature solar turbo-power plant is being developed for pumping water for irrigation purposes as well as for generating electricity to run small agro-based industries in rural areas where power on a small scale usually is supplied by diesel engines. Besides this, the development of a simple pump to be operated by high pressure vapors of low boiling point organic liquids obtained from flat plate collectors without involving the use of a turbine or reciprocating engine is under active consideration.

Cylindrical parabolic reflectors and flat plate collectors of different types have been designed and constructed and are now under investigation. After the performance study, these devices will be used for pumping and electricity generation, as well as for domestic and industrial application. Fabrication of an array of flat plate collectors and cylindrical parabolic reflectors also has been taken in hand.

Solar Salt Production

Evaporation of sea water by solar energy is the only method of salt production in Bangladesh. To increase the yield per hectare, different aspects of the salt beds used by the farmers are under investigation.

Solar Refrigeration

An experimental intermittent absorption refrigeration unit with an ammonia-water system was operated with solar heating provided by a parabolic reflector having a 1.4 meter diameter, and .27 kilogram of ice could be produced per .45 kilogram of refrigerant by an hour of solar hearing heating. Some work on an absorption refrigeration system with various refrigerant absorbent combinations also has been initiated to study the factors affecting the coefficient of performance. After the successful completion of the investigation, a pilot solar ice-making machine plant of about 90 kilograms per day capacity is planned to be set up.

Solar Cooker

In theory, solar cookers can supply as much as 50 percent of the cooking energy needs of the country, but the well-known problems of solar cookers -- the limitations of technology, dependancy on the hour of the day, weather variation, cultural practice and, above all, the cost in relation to the income of the rural people -- are present in Bangladesh also. However, work is going on in research and propagation, and a cooker employing a parabolic reflector with frontial area of 1 square meter and focal length of .46 meter has been constructed. It is claimed that it can cook rice for a family of five to six members in 20 to 25 minutes on a bright, sunny day. Further studies and field trials are in hand for this type of solar cookers. Solar steam cookers, with flat plate collectors having two covers and hot boxes with provision for heat storage, also are being developed.

Solar Thermal

There are bright prospects for immediate low- and medium-temperature application of solar thermal energy in Bangladesh. Appropriate technologies need to be developed locally to meet the specific local needs. Flat plate collectors and parabolic reflectors have been fabricated locally in the past, but experience shows that there are a number of difficulties, especially the lack of materials and trained technicians. These and other aspects, such as storage, must be given active consideration. Paddy pre-heating before parboiling, textiles, sericulture, hospitals, rural health centers, restaurants and hotels are good candidates for use of solar thermal energy.

Solar Photovoltaics

Solar cells have high potential for generation of electricity, particularly for rural use. Considering the potential sizable impact solar power may have on the national economy, particularly in the rural sector, the following steps are being taken for its development:

- Fabrication of silicon cells using the diffusion technique.

- Development of cadmium sulfide and copper sulfide cells.

- Fabrication of silicon wafers.

- Study on electricity generation by solar cell panels under the local climatic conditions and development of storage batteries and other end use equipment such as alternators and DC motors.

Again, emphasis should be given to developing and acquiring technology, keeping in mind that the ultimate aim is decentralized rural electrification by overcoming cost constraints.

Solar Data

Comprehensive solar radiation data is not available for the country, causing problems for study and research in solar energy. There are 42 meteorological stations located in the country which have to be equipped with instruments for recording solar radiation incidences, documenting the data and disseminating the results.

BIOGAS

Because biogas is a kind of fuel gas obtained from anaerobic decomposition of animal and agricultural waste and the technology is claimed to be simple, it is believed to be of considerable economic importance, especially for the rural population. However, unlike some other countries, the maximum potential of biogas is likely to be limited because of the high density of population and the competition for food and fodder between man and animal over limited land mass. It is estimated that the cattle population is about 29 million, whereas the population is reaching 90 million. It is generally believed that cattle population of more than .5 per rural population is needed to sustain biogas units for providing energy above subsistence level for the community. There is a problem in Bangladesh from this point of view, and because 100 percent dependence on cattle is not feasible, human excreta, straw, water hyacinth and crop and vegetable wastes have to be considered seriously, as in China. Given the size of the cattle and the scarce supply of fodder, the cow dung per cattle is believed to be far smaller than the average of 20 pounds used in theoretical calculation in published literature. From the point of view of socio-economic structure (lifestyle, average family size, land holding, income per year, animal per family, the culture of animal-keeping practices and the work of cattle), initial investment for infrastructure, the multipurpose use of cow dung from masonry to manure, and the need to see biogas as an integrated system (including processing end product sludge and effluent), it is unlikely that a major portion of the cow dung will be collected for biogas production. A rough calculation shows that the theoretical maximum possibility of biogas, taking the maximum per capita dung production of 20 pounds per cattle and all dungs as collected and digested for biogas, will give between 9.1×10^{12} and 15.9×10^{12} kcal per year, assuming .8 to 1.4 cft/Kg of dung. Taking the equivalent heat, the maximum potential of biogas would be equivalent to 1 million tons of kerosene. However, it is unrealistic to assume that such large quantities of animal dung can be collected and used for gas production. Only experience will show what is actually feasible in practice.

Present Status and Activities

The biogas industry is still in its initial stage in Bangladesh. Research and plant studies on the production and utilization of biogas are in progress by various agencies, such as the Institute of Fuel Research and Development under the Bangladesh Council for Scientific and Industrial Research, Chemical Engineering Department of the Bangladesh University of Engineering and Technology (BUET), the Agricultural Chemistry Department of Agricultural University at Mymensingh and the Environment Pollution Control Department.

Cow dung from five adult cows can generate enough biogas for daily cooking of a family of six or seven members. A family-size plant (100 cubic feet capacity) with a floating top gas collector using brick, cement and mild steel sheet as construction material costs about U.S. $675. The same plant with a fixed top gas collector using brick and cement costs about U.S. $400. The operation of the former is, however, simpler than the latter. Plants with floating tops and fixed top gas collectors are now in operation in different parts of the country.

Research and Development Program

The Institute of Fuel Research and Development under the Council for Scientific and Industrial Research now is engaged in setting up demonstration plants in different areas, and the institute also provides technical assistance to those willing to set up biogas plants. The Environment Pollution Control Department has undertaken programs for setting up demonstration plants at various locations of the country with a view to disseminating this technology to the rural people. Different government and nongovernment agencies are getting involved increasingly in the dissemination of biogas technology.

Current research activities in the Institute of Fuel Research and Development of the Council for Scientific and Industrial Research, Engineering University, Agricultural University and the Environment Pollution Control Department are directed toward the following:

- Because this technology is meant for decentralized rural application, cost is probably the most dominant factor controlling its wide application. The present cost of more than U.S. $400 for a family-size plant is too high for an average rural family in Bangladesh. Further, research and development work aimed at lowering the cost utilizing local construction materials is needed.

- At present, droppings from four to five cows are needed to get enough gas for daily cooking and lighting for a family of six to seven members. This is because, at the ambient temperature, only 15 to 30 percent of the carbon available in cow dung is converted into biogas. Achievement of higher conversion will reduce the number of cows needed for a family and thereby widen the scope of the applicability of this technology. A special strain of bacteria is capable of giving higher conversion. Further research and development activities along this line will lower the construction cost by reducing the size of the plant, and will reduce the loading rate without decreasing the plant capacity.

- Summer-winter variation in the gas yield by a factor of two makes the gas yield somewhat unpredictable and places the whole technology in uncertainty. A better design eliminating the seasonal variation is needed.

- Because of scarcity of cow dung in many areas, particularly because of the smaller number of cows than the requirement by the majority of the rural families, utilization of other raw materials has become necessary. Water hyacinth may very well fill up this gap. But some kind of pre-processing is required before it can be mixed with cow dung while charging the biogas plant.

- Adequate data on community-size plants and biogas-based integrated farming systems are not yet available. Further work on these systems may make the biogas technology more viable.

- Besides cooking and lighting, utilization of biogas in other fields will widen the scope of this technology.

- The storage of biogas is another problem. Further work aimed at development of a better storage system is needed.

Constraints

Constraints include the socio-cultural living system, high construction costs, uncertainty in technology, lack of public awareness and a dearth of trained manpower.

Recommendations

(a) Because both the raw materials and technology are locally available, a national policy for widespread use of this technology should be considered, taking into consideration the constraints mentioned above.

(b) Because widespread use of this technology will reduce pressure on conventional fuels, an international fund may be made available for financing the research and development program for sharing biogas failures and success.

(c) Frequent regional seminars or workshops aimed at exchanging ideas and training personnel for the dissemination of the development of the technology are needed.

(d) Institutions engaged in research and development activities on biogas should be strengthened in funding, facilities and manpower.

(e) Mass media should be activated to create public awareness for this technology.

BIOMASS

In Bangladesh, government forest covers about 9 percent of the total land surface. Deforestation, reaching alarming proportions, has been going on for the following reasons:

- Increase in the population.
- Indiscriminate felling of trees for industries and construction of houses.
- Claiming of land for agricultural purposes.
- Shifting cultivation by some tribal people.
- Fuel wood collection for cooking and burning of bricks.
- High prices of timber and fuel.

Being situated in fertile tropical land, Bangladesh's prospects of biomass production is high if there is proper planning and management. As the land area is limited and production of food gets priority over production of biomass for fuel, the only land available for energy plantations are slopes of roads, coastal embankments, railway lines, canal banks, farmland ridges, compounds of homesteads, educational institutes, and spaces in mills and factories.

The areas where the multipurpose species can be grown are as follows:

Slopes of roads and highways	2,885 miles
Roads maintained by local Government institutions	87,000 miles
Railway	1,786 miles
Banks of Tanks	22,00,000 Nos.
Compounds of mosques	over 2 lakhs
Farmland ridges	nearly 2,000 square miles
Compounds of factories and educational institutions.	

Ideal energy farming will be an optimum balance of the product in terms of food, fodder, timber and raw material for coattage industries. Giant lpil lpil, Korai, Australian Accasia, Eucalyptus and other species are going through field trials in the country. In the planning for rural energy needs, plantation of short-cycle plants to provide firewood and other uses has to have the highest priority.

Peat

Peat is available in many parts of Bangladesh and the average of dry peat has been estimated at 133 million tons. The average chemical analysis of a typical air-dried peat sample as follows:

Moisture	6.48 percent
Ash content	32.96 percent
Volatile matter	45.04 percent
Fixed Carbon	15.52 percent
Calorific value	5,905 BTU per pound

Briquette tests and the test burning of peat in brick kilns are reported to be encouraging. However, further tests are necessary before peat can be commercially utilized for domestic or industrial purposes. The problems with the peat extraction are related to the nature of deposits where the peat fields are good rice-growing areas. It is to be determined if extraction of peat and subsequent reclamation of the area for rice growing or agriculture is feasible. If it is found that peat can be extracted without disturbing the agricultural and ecological balance, then the peat project can be taken up seriously.

WIND ENERGY

From existing meteorological information, it appears that Bangladesh will have limited wind energy potential. However, areas near the shore line of the Bay of Bengal have higher wind velocity than the inland area of the country. The Chittagong Airport area, which is near the coast line, has a wind speed of about 4 meters per second or more for 3,000 hours in a year whereas 6 meters per second is available for 1,650 hours per year. The most probable wind speed is 1.6 meters per second. The maximum hourly mean wind speed over the year is 5.7 meters per second, occurring at the fourteenth hour of the day, whereas the minimum is about 2.6 meters per second at the second hour. The yearly average wind speed is found to be 3.2 meters per second. Among the locations measured for wind speed, Teknaf, on the southern tip of the coast line, has shown highest wind velocity.

Because the wind speed is not high, wind energy cannot alone take care of the rural energy need. It may only supplement commercial and other sources of energy. Wind may, however, be used for agricultural irrigation or for electric power generation, depending on the location of the site.

Present Status of Activities

The research and development activities in the field of wind energy are almost non-existent. At present, only a few educational institutions have taken up some preliminary projects covering different aspects, as indicated below:

- Wind data, as recorded by meteorological stations, is being analyzed in detail. Some inaccuracies, defects and limitations in recording the data have been detected.

- Small vertical axis wind turbines, like the Savonius, sailwing and vertical blade Darrieus, are being developed. A sailwing rotor coupled with a diaphragm pump has been tested for lifting water. Results are encouraging. The starting speed for the system was found to be only 1.5 meters per second, with a maximum overall efficieny of about 10 percent. A performance study of a small Savonius coupled with a diaphragm pump is being carried out. In all the cases, emphasis is given on the utilization of indigenous materials.

- A vertical blade Darrieus having a height of 4 meters and diameter of 5 meters with NACA 0015 airfoil (chord-0.97 meters) has been designed and is under consideration. It would use locally available materials. It will be tested in the Chittagong Airport area and is expected to generate about 1 KW for driving a positive displacement pump.

- A Cretan-type sail windmill has been designed and is under construction. Again, emphasis has been given on the utilization of locally available materials.

- A horizontal axis multibladed turbine was received as a gift from abroad and installed, but no comprehensive tests were carried out.

Recommendations for Future Research and Development Program

As wind energy, combined with other sources, may contribute reasonably to the energy of rural Bangladesh, active consideration must be given to the following:

- Wind data at many locations other than the meteorological stations should be recorded accurately and analyzed. Arrangements should be made for proper documentation and dissemination of the information among the people and organizations involved.

- Wind turbines for lifting water for irrigation and drinking purposes, through a head of 3 to 10 meters, should be developed, keeping in mind the socio-economic condition and the need to use indigenous materials. Both community and individual modes of operation and storage should be considered. Appropriate coupling pumps also will have to be adopted, improvised or developed.

- Electric power generation by wind energy for isolated villages in the coastal areas and offshore islands may be considered. At present, the power requirement for such a village is estimated to be between 15 and 20 KW. Proven wind turbines, generators and storage facilities may be selected as pilot projects before their large-scale use can be recommended.

- A performance study of the conventional sails used for propelling boats should be made and recommendations may be put forward for possible improvements in the traditional use of wind energy.

HYDROELECTRIC ENERGY

Total hydro potential of the country is limited because the country is a flat basin and the northern part declines from a height of only 85 meters to sea level in the southern parts over a distance of 400 kilometers, giving a slope of 1 to 4,700. Thus, although there is a run-off of about 100 million acre/ feet of water over an area of about 36 million acres, there has been no major source of hydroelectricity, and, as mentioned earlier, the total potential has been estimated as only 1,300 MW. No serious consideration was given to the potential of small hydro projects in Bangladesh. It is only recently that the Bangladesh Water Development Board and Power Development Board together conducted a Reconnaissance Survey in four small areas to identify mini-hydro sites on a number of streams. The preliminary results of this survey are reported to be encouraging. Multipurpose irrigation projects are being given consideration for the generation of hydro power. In an irrigation barrage in northern Bangladesh, it is assumed that with an average flow of 170 cusec and at an assumed head of 3.65 incyes, 45 GWh can be generated. For harnessing this energy, axial flow bulb-type turbines have been recommended. Similar potentials have been identified at another barrage with a possibility of harnessing 179 GWh, employing 15 2.5 MW axial flow bulb turbines. There are innumerable small rivers, streams and some minor waterfalls in the country, but in the absence of a detailed survey, the potential of small hydro cannot be given. In full monsoon, there may be innumerable sites for mini- and micro-hydro potentials for very short periods of time.

Research and Development Needs

A comprehensive survey of the country for small and mini-hydro may be undertaken to know the potential of this energy source. International, regional and bilateral cooperation will be helpful for the sharing of experience in this field.

GEOTHERMAL

At present, there is no known geothermal source in Bangladesh. However, the structural geology of Bangladesh indicates certain places with potential in the northern slope of the Rangpur saddle and also, to some extent, in the southern slope where low permeability lithology combined with high underground temperature may exist with potentially suitable bodies of crystalline rock (for example, granodiorite). Structural geology of the folded region of Chittagong and Chittagong Hill Tracts are also prospective zones, especially where the hot spring of Sitakund already exist.

The preliminary borehole information suggests that the strata temperature at or about 3,000 feet below in the southern slope of Rangpur saddle is about 125^{o}F. But no exploratory hole has been made in connection with harnessing geothermal energy. Data on the prospect of geothermal energy is not yet available, as this is a comparatively new aspect in the energy resource inventory in Bangladesh. The conditions in the deep-seated formations beyond basement rock need to be studied.

No effort has been taken on the investigation of geothermal sources in the country. Expertise in the field is scarce. Information pooling on a regional basis will be of much benefit to Bangladesh. Expert services in the field also will be helpful in surveying and investigating this source.

OCEAN ENERGY

Awareness that ocean energy may be of some value in Bangladesh is recent. Thus, although the south of Bangladesh lies on the Bay of Bengal, no attempt was made to investigate the potential of ocean energy in Bangladesh. A comprehensive study covering ocean thermal gradients, tides, waves, currents and salinity gradients would be in order now.

Based on observation of different sources, it is known that tides in the estuaries of Bangladesh are semi-diurnal in nature with a period of 12 hours 25 minutes. There are pronounced diurnal variations in high water levels due to the moon's declination. The phases of the moon, upland discharge and cyclonic surges have pronounced effect on the high and low waters of these estuaries. Tide range in general varies between 3 and 6 meters.

No reliable estimate of the potential of ocean energy is available.

CONCLUSION

It has been stated that roughly one-third of the total estimated energy need of the country is supplied by commercial fuels, of which about 50 percent consists of imported petroleum and petroleum products. The need for petroleum products, nearly 50 percent being diesel, has a direct bearing on the rural economy in meeting the fuel needs for irrigation pumping and transportation. Another 30 percent, in the form of kerosene, provides fuel for illumination as well as a very small proportion of heat for cooking. Neither rural electrification nor natural gas has yet reached the rural consumers in any significant way. Dramatic increases in the price of oil meant gradual denial of basic supplies of energy to rural people affecting both their economic activities and the standard of living.

The traditional energy sources account for two-thirds of the total energy needs. The main supplies have been cow dung, rice straws and husks (accounting for an estimated two-thirds of the total traditional energy) and firewood, leaves, twigs, bagasses and other agricultural wastes. Thus biomass has played a major role in the energy balance of the country, touching directly as well as indirectly the life of 90 percent of the population. But the low and gradually dwindling land-person ratio and the increasing landlessness for a large cross-section of the population have been posing problems in development and utilization of biomass energy.

Firewood is the most important source of fuel for cooking and heating. Excessive deforestation has started serious environmental degradation and begun the process of dessertification. Scarcity has shot up the price of firewood beyond the means of most people. The landless, the disadvantaged classes of the society and the low-income groups have been the worst sufferers. Gazari, a popular species of firewood, which was selling at Tk. 26 per maund (82.3 pounds) in 1978 has touched Tk. 50 per maund in 1981. At this price, given the low efficiency of thermal conversion for traditional "chullis" or stoves using firewood, firewood has become, in real terms, more expensive than the imported kerosene.

The crunch of the high price of imported fuel and the scarcity of domestic fuel for the rural masses have compelled Bangladesh to look for alternative sources of energy to prevent further deprivation and degradation of life. With the availability of natural gas and some other sources of domestic fuel, an integrated approach for development of commercial and renewable sources of energy has become necessary, in which the argument for adequate emphasis on renewable sources is abundantly clear. In the renewable category, while time has to be allowed for removing the constraints of technology and cost, some forms of renewable energy with bright prospects such as solar photovoltaic or biogas, massive programs for short cycle tree plantation, preferably for multipurpose use as fuel and fodder need no further delay. However, in all the possible programs for development and use of new and renewable sources of energy, the need for collaboration on technology, methods, access to research results, and, above all, finances stands out as paramount.

China

CONTENTS

INTRODUCTION

China is an agricultural country. For generations the laboring people depended on cattle for cultivation, firewood for cooking, horses for travel, junks for sailing, water power for milling, wind power for pumping, solar radiation focusing for fire, and hot spring baths for treatments. This indicates that massive utilization of new and renewable energy sources such as biomass, solar energy, wind power, hydro power and geothermal energy has a long history in this country.

The founding of the People's Republic of China in 1949 put an end to the long-standing reactionary rule in old China. The Chinese people have developed industrial and agricultural production. Independent branches of industry in coal, petroleum and electricity gradually were established, providing various sources of energy for socialist economic constructions. However, energy consumption in China increases rapidly along with the constant growth of the national economy. Currently the insufficiency of energy has become a prominent problem in the development of the Chinese national economy.

Because the Chinese rural population covers more than 80 percent of the total, the solution of rural energy problems means a solution of significance. New and renewable sources of energy not only have a history of traditional use, but also serve as a major means for meeting rural energy requirement and may bring about benefits to industrial and agricultural production as well as livelihood of urban and rural inhabitants. Consequently, in addition to the efforts devoted to developing conventional energy sources and in reducing energy consumption, the Chinese government also puts emphasis on the development of new and renewable sources of energy, in the hope of making full use of various resources for China's modernization.

BIOMASS

Biomass is a major component of current Chinese energy. It constitutes more than one-quarter of the total energy consumption of the country, equivalent to 220 million tons of standard coal. Biomass plays a significant role in meeting the daily energy needs of broad masses of Chinese people because the fuel in the vast countryside of China comes basically from biomass in the form of firewood and straw. The biomass is commonly utilized by direct burning, and the heat efficiency is as low as 10 percent, causing a loss of organic fertilizers, reduction in soil fertility, destruction of the ecosystem and pollution of the environment. Therefore, strengthening scientific research to improve the utilization of biomass is an important task facing us.

During the late 1950s, mass experiments on biogas emerged in Chinese rural areas, but most of them were given up because of insignificant success owing to lack of technical guidance. In the early 1970s, experiments on small-scale biogas digesters for domestic use resumed in an organized way in some areas of Sichuan province. The peasants improved the technique in building water-pressured digesters, enabling them to satisfy their practical needs. The government summarized the experience and convened an experience-exchanging conference. Families were encouraged to build biogas digesters with various forms of appropriations, such as bank loans and subsidies from production teams and communes, and a series of problems related to production and supply of construction materials and necessary apparatus are being dealt with. Training courses on biogas technology had been sponsored in quite a few places to train technicians for the production teams. Biogas production thus was spread rapidly all over the country.

By 1975, when the first nationwide experience-interchanging conference on biogas was held, 460,000 small digesters for domestic use were built in various places. By 1978, when the second conference was convened, the number was increased to 6.39 million. Some large digesters for electricity and power generation were available then. In view of this swift development of the situation, the national Leading Group for Biogas Development and National Office for Biogas were set up in 1979, when biogas research institutions were organized as well in provinces such as Sichuan, Gyangdong, Jiangsu and Zhejiang. Now more than 40 institutions have undertaken research on biogas, and "Biogas Science & Technology" magazine began its publication in 1980. The development of biogas had been incorporated in China's national economic program as an important part in the modernization of agriculture.

Benefits from biogas utilization are obvious. Firewood and straw are conserved, organic fertilizers and agricultural production are increased, housework is reduced, the environmental conditions improved and general satisfaction is achieved in the communes and production brigades where biogas is properly utilized. The successful experiences reinforced the peasants' confidence in finding solutions to the rural energy problem. Being economical, reliable, effective and endurable are necessary qualifications for successful development of biogas. During the past two decades, considerable efforts have been made in studying digester models. The design of water-pressure digesters has been improved by adopting coating and cement pasting layers to prevent leakage caused by excessive inner pressure. Now the investment cost for a 10 cubic meter digester is about 70 to 100 yuan RMB. Such a digester produces 1.2 to 1.5 cubic meters of biogas per day, enough to satisfy the energy need of cooking and lighting for a family of five.

However, disequilibrium exists in the development of biogas utilization from place to place. In some areas, owing to rapid expansion without proper technical guidance and scientific management, or to the limitations of local materials and conditions, the digester construction fails to reach technical requirements. The digesters were rather low in gas production and unable to play their proper role. That is why a policy of readjustment has been adopted in the past two years, which involves slowing down the construction speed of new digesters with emphasis on restructuring the 7 million digesters that already have been built. The aim is to reconstruct or to abandon digesters which failed to perform their proper function, as well as to develop some new ones of higher quality. Furthermore, digesters of other types also have been constructed, and larger mesophilic digesters and digesters using industrial organic wastes and/or urban sewage as raw materials also have been constructed. Research has been organized on adjusting the digester structure, expanding sources of fermentation materials, mechanical discharging, and improving fermentation technology as well as heat efficiency of stoves in biogas utilization, to achieve a sound technological basis for the further development of biogas utilization.

The major policies and measures taken in Chinese rural areas are:

- Progressive expanding guided by typical examples. Peasants believe in reality. A new technology could be expanded only when, through the establishment of convincing examples, it is accepted by the peasants. At the early stage of expansion in Sichuan province, efforts have been focused first on establishing a number of demonstration digesters in a district of Mianyang City, which solved fueling problems for the peasants and contributed to a good harvest by supplying humic acid manure out of the digester sludge, thus demonstrating the benefits of biogas to agricultural production as well as to the livelihood of the masses. Hence there was a rapid expansion throughout the city. By 1975, the utilization of biogas was spread over the whole city of Mianyang and its agricultural production has increased. With development of biogas, soil was properly managed, resulting in a considerable decrease of parasitosis such as schistosomiasis.

- Focusing the development of biogas in areas short of firewood and where schistosomiasis prevails. This order of priority meets the urgent requirements of the masses and also makes the expansion easier.

- Developing biogas utilization district by district in a planned way to facilitate provision of technical guidance and scientific management. Low quality waste digesters had been turned out in areas where people were in a hurry to obtain quick results at the early stage of biogas development, wasting both manpower and materials and dampening enthusiasm. Now an increasing probability of success is achieved by stressing individual responsibility -- who builds the digester is responsible for it.

- Bringing supply of funds and materials for construction of biogas digesters into line with the state and local government plans. Peasant households should raise funds for the construction mainly on their own, with subsidies from the communes and the state as supplementary means.

Higher subsidies are supplied to newly developed areas by the government and the collectives. Low-interest or interest-free loans are provided to the peasants through the national banks, while the materials for digester construction are supplied by the production teams and the government. The related government departments appropriate part of the funds for development and maintenance of biogas digesters. A research fund of a fixed amount is allocated every year for the improvement of biogas technology in gas production, rate of combustion and extermination of germs and bacteria.

- Establishing biogas management systems, taking into consideration both the interests of peasants and the collectives. The means of production in Chinese rural areas are owned chiefly by the collectives. The ordure and crop stalks are owned mostly by the production teams and used mainly as fertilizer. How to distribute these residues as raw material feed for digesters and collect the discharge as fertilizer is a very important question. Certain plans and measures regarding raw material feed for digesters and use of manure from digester have been laid down in line with the practical condition there. The collectives pay the peasants for the manure, and the manure needs of both the production teams and the commune members' private plots were taken into account.

Biomass energy is an important branch of new and renewable sources of energy, while biogas is merely one aspect. In recent years, China has been cultivating energy plants and firewood forests in addition to the vigorous development of rural biogas. Attention also has been paid to the modification and spreading of advanced firewood stoves, to reduce firewood consumption and environmental pollution. Furthermore, in some institutions, studies which may have a significant effect upon future development of biomass energy have begun. They focus on gasification of solid biomass, hydrogen generation through photosynthesis and enzymatic hydrolysis of cellulose and lignose. The advance of such studies indicates a tremendous potential and a promising prospect for biomass energy.

SOLAR ENERGY

China has abundant solar energy resources, with an annual insolation of more than 2,000 hours. Two-thirds of China has total solar radiation greater than 140 kcal per cubic meter per annum.

As a modern energy technology, solar energy research and development started in the mid-1970s. In recent years, the Chinese government has paid much attention to solar energy research and development, and encourages people to utilize solar energy. Two national solar energy application conferences were held in 1975 and 1979; the Solar Energy Research and Development Program was worked out then. The China Solar Energy Society was organized in 1979, and two magazines, "Acta Energiae Sola ris Sinica" and "Solar Energy," started publication in 1980. In most of the provinces, solar energy research work has been undertaken. A solar energy technical contingent is being built up. A few solar energy demonstration spots have been established. Some solar energy application devices that can be easily popularized and beneficial are developing rapidly throughout the country. A number of solar energy device manufacturers, which produce solar collectors, solar cookers and photovoltaic devices, have been set up to meet the increasing needs. In view of this situation, we believe solar energy device production in China has begun its industrialization.

Solar cookers have been used widely in areas rich in sunshine but lacking fuels. The cookers are highly appreciated by the peasants. These solar cookers are manufactured locally with local meterials, so the cost is as low as 40 to 50 yuan RMB each, which could be afforded by most of the peasants. The trial production and dissemination fees are partly funded by the state. There are more than 2,000 solar cookers in daily service. They will be further expanded and are planned to be comprehensively used with biogas- and firewood-saving stoves to ensure cooking energy supply to peasant families.

The solar heater is one of the major items being popularized. In large cities, such as Beijing, Shanghai, Tianjin, Guangzhou and Wuhan, solar collectors now are being used for hot water supply to public bathrooms, hotels, hospitals and offices. There are about 100,000 square meters of flat plate solar collectors in service in China. Most are tube and sheet type, and some are flat integrated channeled or other types. In order to reach high operating temperatures for thermal performance, the glass vacuum tubular collectors and parabolic trough concentrating collectors also are being developed. Ceramic enamel or plastic collectors are under pilot study. Various kinds of solar driers have been put on probation to dry tobacco, jujubes, medicine herbs, rubber, mushrooms and grain and timber. Plastic solar greenhouses are being used in vegetable plantations over a vast area of 6,000 hectares in total. These facilities are technologically and economically practical.

In China, silicon solar cell production has a history of more than 20 years. Since the 1970s, a comprehensive utilization of single crystal silicon has begun. The manufacturing technology of solar cells has been improved and their costs reduced rapidly. Silicon solar cells have been extensively used in beaconing lights, railway signals, electric fencing, television repeaters and communication. At present, in order to reduce the cost, improve the photoelectric conversion efficiency and extend their fields of application, polycrystal silicon, amorphous silicon, cadmium sulfide and gallium arsenide solar cells are being developed.

The passive solar houses being tested will play an effective role in energy conservation and in space heating. Recently, several passive solar houses built in northern and northwestern China have achieved initial success. Because their cost is low, they will influence retrofit style of older houses in rural areas of northern China.

Scientific research in solar energy is being carried out extensively. In addition to the specialized research institutions, some basic and applied research is done in universities, factories and other institutes. Our government gives necessary support in funds, materials and trained personnel, and the policy is to encourage the activities of the scientists and technicians, bring their initiative into full play and help the application departments to speed up trial and expansion of new technology. However, our level of solar energy technology is not advanced. Generally speaking, it is still in an experimental stage. For those technologically feasible and economically reasonable solar devices, we will perfect them step by step and put them into extensive use.

China has a long history of wind energy utilization. In middle and southern China, some civil water transportation in the river network still relies on sailing boats. There were about 600,000 tons of cargo transported by junks in 1979. But during the past two decades we have not paid enough attention to the development of wind energy, and have replaced some traditional uses of wind energy with electricity. Consequently, the shortage of electric power supply in rural areas was sharpened. In the past two years, every part of the country has realized the importance of making full use of energy resources available, and the utilization of wind energy again has drawn the attention of people. Now some small wind turbines have been developed in the Inner Mogolia Autonomous Region, Gansu and Zhejiang Province, and their power varies from 100 watts to 10 KW. Some 18 KW and 40 KW wind turbines were equipped with old helicopter propeller blades. In view of the real technical and economic situation in China, we plan to develop the small wind turbines first, and then put our emphasis of wind energy development on those remote regions with rich wind energy resources but lacking conventional energy resources.

HYDRO POWER

The hydro power potential in China is abundant, with a total theoretical capacity of 680,000 MW, of which 370,000 MW could be exploited economically. However, 70 percent of the hydro power resources spreads over the sparsely populated southeastern part. The hydro power potential already exploited and utilized is only 3 percent of the total. Therefore, the potential of hydro power resources in China is very great. The development of small hydro power will be one of the focal points in the future energy development of China.

The guiding principle of development of hydro power in China is the combination of large-, medium- and small-scale stations. Eighteen large hydro power stations (larger than 250,000 KW) have been constructed. They total a capacity of 8.15 million KW -- more than 40 percent of total electricity capacity from hydro power. There are nearly 90,000 small hydro power stations of less than 12,000 KW, with a total capacity of 6.8 million KW, more than 30 percent of the total electricity from hydro power. The rest are of medium scale.

The largest hydro power station in China is Liujiaxia Hydro Power Station on the upper reaches of the Yellow River, which has a concrete gravity dam 157 meters high, a 5.7 billion cubic meter reservoir and a 1.225 million KW installed capacity, as well as an annual electricity generation capacity of 5.7 billion KWh. The Gezhouba Hydro Power Station, being built on the Yangtze River, the longest river of China, has an estimated capacity of 2.7 million KW.

The large hydro power stations are financed and managed by the state; the medium ones are built by the provincial, regional or the central governments; and the small-scale stations are constructed and managed by the counties, communes or production teams, because mini-hydro requires less technology and investment. The state supplies appropriate subsidies or loans and practices a policy of "owned, managed and profited by those who built them." More than 1,500 of the 2,000 counties in China have built mini-hydro stations, covering about 40 percent of the agricultural electricity consumption. Mini-hydro has played a proper role and is well accepted, especially in remote mountainous areas and the areas inaccessible to large grids.

TIDAL POWER

China has a coastline longer than 18,000 kilometers, and a tremendous reserve of tidal power. The estimated exploratory tidal power capacity is about 28 million KW, with an annual electricity generation capacity of 70 billion KWh. However, only several small tidal pilot power stations have been built along the coast of Guangdong, Zhejiang, Jiangsu and Shandong provinces, with a total capacity of 6,300 KW. The Jiangxia Tidal Power Station, recently built in Zhejiang Province, has a designed capacity of 3,000 KW, and a 500 KW generator set already in operation.

GEOTHERMAL ENERGY

China is relatively rich in geothermal resources. There are about 2,500 natural hot springs and partially exposed underground hot water deposits in this country. The hot springs mainly exist in provinces along the southeastern coast, and in Tibet, west Yunnan and west Sichuan in the southwest. In the two zones mentioned, hot springs are not only large in number but also high in temperature, forming two medium- and high-temperature geothermal zones, designated as Pacific Oceanside Geothermal Zone and Tibet-Yunnan Geothermal Zone, respectively. The Pacific Oceanside Zone involves Chinese Taiwan, Fujian and Guangdong provinces as well as east Liaoning and the Shandong peninsulas, possessing nearly 600 hot springs which are equivalent to about one-quarter of total outcropping hot springs in this country. High temperature hot springs in this zone mostly exist in Taiwan Province. The temperature in the Macao area reaches 293°C. Those in the provinces on the continent are mostly medium temperature hot water deposits of about 100°C. The Tibet-Yunnan Zone is the most violent area of hydrothermal activity in China, possessing a large number of fountains and vapor springs. There are about 500 hot springs discovered in this zone, and some 100 hydrothermal activity areas of intrinsic temperature higher than the local boiling points. At Yangbajing geothermal field, now under exploration, steam of 171°C is obtained from drilled holes more than 200 meters deep. The temperature measured in 12-meter shallow holes in Tengchong geothermal field in Yunnan is 145°C. Numerous hot springs are also distributed in other areas in China, but mostly with water temperatures below 90°C.

Geothermal energy is utilized in the livelihood of the Chinese people as well as in industrial and agricultural production. Underground hot water was used in medical treatment and domestic usages before the 1950s, and in industry and agriculture in the 1960s. In the 1970s, the resources were considered as a new source of energy and larger scale investigation, research and utilization followed. Geothermal energy now is used in electricity generation, industrial processing, domestic space heating, agricultural greenhouses, aquaculture and medical treatment. The utilization of geothermal energy has yielded fine results in coal saving, transportation reduction and pollution alleviation.

However, the exploration and utilization of geothermal resources in China is, in general, at a preliminary stage and in a small scale of productive utilization. In light of the features of Chinese geothermal resources and the potential of current economy and technology, the major policy in a period to come is to carry out surveys, exploration and comprehensive utilization of geothermal energy in a planned way, and with certain priority.

OTHER RENEWABLE RESOURCES

Other new and renewable sources of energy, such as animal power, oil shale and peat, also are utilized and developed to varied degrees. Animal power is extensively used in our country. The use of cattle, horses, mules, donkeys and oxen to pull carts and till farms has played an important role in the history of our country. Using oxen to cultivate farms is still quite common in Chinese villages, especially in hilly areas and irrigated farms with varied topography. Most farm products still are transported by horsedrawn carts in the northern rural areas. According to China's geographical features and technical and economical conditions, animal power will play an important part for a rather long period in the future. Because the state could not provide enough petroleum products to meet the rural needs due to the energy shortage, further development of animal power has real significance. We have 50 million head of such draught animals as horses and oxen. It is predicted that animal power will increase considerably in the near future, along with the increase of agricultural production.

The oil shale deposit in China is quite rich and is dispersed over Liaoning, Guangdong, Jilin and other provinces. In some areas the oil shale deposit is not deeply buried and the layer is quite thick, suitable for opencast mining. The oil shale industry in China has a history of several decades and produces mainly the shale oil and its byproducts by way of dry distillation. Since the founding of the People's Republic, the shale industry has expanded rapidly. The type of furnace and the processing technology both have been greatly improved and developed. Shale oil refineries were established in Liaoning and Guangdon provinces. Some research and development works on oil shale are carried out in these refineries. The development of shale oil processing levels off because of the extensive exploitation of raw petroleum. The present annual production of shale oil in China amounts to 300,000 tons, but there are still many areas in production, equipment and technology to be improved.

Peat is also one of the valuable natural resources. It has a wide use in industry, agriculture and medicine. China has a rich peat deposit, approximately 8.5 percent of the world's reserve. But before 1960, no systematic investigation or exploration was carried out. Thereafter, a nationwide survey of peat resources was organized and a study was carried out on its utilization in many fields -- for instance, as domestic fuel or fuel for baking, to brew high quality liquor, as an ingredient of fertilizer, fiber board and light-weight insulation brick, and as raw material from which acid is extracted. Full utilization of peat represents an important course to take.

CONCLUSION

Energy is closely related to the development of the national economy and the improvement of the living standard. Presently, the main energy resources are still the conventional ones -- coal, petroleum and natural gas. From a global view, the tremendous consumption of conventional energy and its ever increasing growth constitute an obvious threat to the limited resources. Despite the fact that energy resource conditions vary from country to country, the shortage of conventional energy is, to a certain extent, common to all countries. And China is no exception.

Undoubtedly conventional energy still holds positive dominance within this century, but the strain will increase daily. In the 21st century, the decreasing resources and rising prices of conventional energy will reach such a point that the present development of conventional energy will lose its momentum and will leave its place to new energy. According to historical experience, a transition period of several decades is needed to complete every significant revolution of energy. If we do not now place new and renewable energy on the agenda, a serious situation of temporary energy shortages certainly will arise in the 21st century. Based on this understanding, the Chinese government is undertaking research and development on new and renewable sources of energy. Because China is a populous and large country, and a developing country as well, we have to develop our new and renewable energy according to our specific situation. At the same time we wish to learn the advanced technologies and experiences of other countries, to establish extensive international scientific and technological cooperations.

Indonesia

CONTENTS

INTRODUCTION

Indonesia has witnessed a rapid growth rate of energy consumption in the past several years. This trend is understandable, of course, in terms of the economy's initial relatively low energy base.

Indonesia fortuitously has been endowed with copious hydrocarbon energy reserves, and the current production level enables it to be a net exporter. Moreover, oil and natural gas are Indonesia's most important sources of export earnings, and they are important for achieving its development goals. At the same time, given the current energy surplus and the Indonesian economic situation, it may be advantageous to subsidize alternative energy sources for domestic needs. However new and renewable sources of energy, if indeed they materialize, could play an important role in meeting the inevitable increase in domestic demand for energy and thus release such subsidy funds for other development purposes.

The transformation of domestic energy consumption is taking place for several reasons. It is both a function of the rise in population and the degree of national economic activity. What has been insufficiently recognized, however, is that it is difficult to keep energy development apace with the growth rates of these two variables. Furthermore, there are constraints on energy development at the rural level, including such factors as inefficiencies of scale, the lack of financial resources and the reluctance to invest in new facilities.[1]

A pervasive and major source of energy at the rural level is firewood.[2] However, changes from its traditional cycle of production rate and functional use could have severe environmental impact, not the least being soil erosion and degradation.

While gaps in understanding the role of energy in rural areas still persist, energy has become an integral part of rural development. Thus it is imperative that local resources, such as the availability of skills, leadership, financial resources and marketing systems, be developed and mobilized for energy production.

ENERGY PROFILE

Oil, Natural Gas and Coal

Indonesia has appreciable amounts of hydrocarbon energy sources including oil, natural gas and coal. Recoverable deposits of oil are estimated at approximately 50 billion barrels. Production levels reached 570 million barrels in 1980.

Natural gas deposits are estimated at about 30 trillion cubic feet, with a production level in 1980 of about 1,048 million cubic feet. However, 27 percent of this is still being flared.

As for coal, possible reserves in Sumatra are calculated to be about 15 billion tons, with proven reserves up to 600 million tons. Coal reserves also have been found in Kalimantan, but the quality has not yet been assessed. Pre-war production of coal reached a total of 2 million tons, while current production is about 300,000 tons a year. If this annual figure is increased, production costs can be reduced to about U.S. $30 per ton at the pitmouth.

Firewood

As in many developing countries, firewood has been and still is a major and extensive source of domestic energy. This is especially true in rural areas for cooking and heating purposes. Currently we do not have comprehensive or accurate data on either the consumption or the production of timber for firewood, but it is estimated that firewood supply is about equal to the firewood consumption, which contributes about 50 percent of the total energy consumption and 80 percent of the needs of the rural areas.

Other Energy Sources

Many other conventional and unconventional sources of energy have been investigated and some are in use, but they represent only marginal significance to the nation's overall energy usage. These include hydro power, which has an estimated hydroelectricity potential of 31,000 MW and widespread possibilities for further small-scale electrical generation, and geothermal, biomass and biogas, solar, wind, ocean and even nuclear energy.

Infrastructure Development and Rural Electrification

Rural electrification is proceeding at a rate of approximately 600 villages per year. At present, only 7 percent of the 61,000 villages have been serviced, supplying about 3.5 million people. Steps are being taken to expand the electrification scheme on three broad fronts. These include the expansion of the existing grid, the promotion of a micro-hydro development scheme and the installation of diesel generators in remote areas as an interim measure. Major constraints, however, including the lack of adequate funding and the availability of skilled manpower, hamper its implementation.

Management of the rural electrification program has been given to one of the community institutions at the village level, as is prescribed by the philosophy of rural development. This philosophy requires that people participate in rural development at all stages of planning, implementation and evaluation.

Law No. 5, 1979, stipulates that, to promote and develop the "gotong royong," or mutual help spirit of the villagers, it is necessary to strengthen coordination activities by means of village institutions, including village social committees, neighborhood associations and citizens wards. At the Kecamatan, or group of villages level, management participation also has been established. Plans formulated at these grass-roots levels are submitted to higher levels of government for clearance. Government support for both managerial and technical training has been provided, and models for the promotion of cooperatives and the State Electricity Corporation have been developed for future implementation.[3]

Energy Consumption

Two major trends are detectable in the domestic consumption of energy in Indonesia. First, its growth rate has rapidly changed from an average of 10 percent per annum during the first five-year plan (1969-1974) to 15 percent per annum during the second five-year plan (1974-1979). The second trend is that oil, although still the dominant source of energy in Indonesia's commercial energy mix, has a decreasing role and stands at about 80 percent today. Natural gas and even coal are increasing their proportion in the domestic commercial energy composition. Domestic consumption of coal increased 46 percent to 190,426 tons in 1980 over the previous year, while exports consisting of anthracite and steam coal reached 100,465 tons.

The share of commercial energy consumption is about equally distributed among the three major sectors of the economy and has not shown any considerable variation in recent years. However, if we include non-commercial energy consumption, which is mainly used in the household sector, this sector would have the largest share.

Energy in the form of electricity has expanded during the past decade, showing an increase in installation capacity of 1,621 MW, which represents an average increase of 24 percent per year. Nevertheless, the per capita installation capacity is only about 16 watts and covers only 7 percent of the population. The increase in public electricity supply in the past two years has reached an average of 3 watts per capita per year.

Preliminary assessments show non-commercial energy consumption is relatively large and, although this is declining, it still contributes up to 50 percent of total energy consumption. More precise data on non-commercial energy is being collected. Current data relates mainly to firewood, which is the primary source of fuel in rural areas. One of the measures to offset this pervasive use of firewood is the introduction and distribution of kerosene. This apparently is possible only with substantial subsidies, and its importance is still limited outside of urban centers.[4] The demand for firewood continues to increase at a rate of 3 percent to 4 percent per annum, which is larger than the population growth rate. Its total consumption was estimated at about 39 million tons in 1980.

ENERGY POLICY

The core of Indonesia's energy policy is to guarantee that domestic energy supplies are available to meet domestic demand quantitatively, qualitatively and at affordable prices. This policy has the objective not only of improving the welfare of the Indonesian people but also of providing the necessary support for rapid socio-economic growth.

Energy policy formulation is based on one of the founding principles of the state: that land, water and natural resources are state-owned and should be used for the optimum welfare of the population. Given these principles, the following policy measures are recommended:

- The formulation of a comprehensive and integrated energy policy, based on the development and utilization of these resources and taking into account both domestic and export growth in demand; and development of a long-term strategic energy supply.

- The conservation of oil-based energy, the main energy source, and the development of non-oil energy resources such as coal, hydro power, wind power, geothermal energy, nuclear energy and solar energy.

- The development of cheap energy supplies in rural areas which minimize damage to forestry, land and water.

- The increased development and management of mineral resources, in particular energy minerals, due to their role as foreign exchange earners for the financing of national development.

- The establishment of a national energy policy which is fully supportive of national development.

- The increased development of electric power, both in rural and urban areas, for the purpose of improving the welfare of the society in general and for triggering economic activities.

To facilitate the achievement of these objectives, a major policy measure is the economization and more efficient use of oil resources to maximize their value, both indirectly for earning foreign exchange and directly as a fuel for national development. This step can be strengthened by the use of available oil substitutes, which, due to their site-specific nature and low heat quality, cannot be exported economically.

Measures to accomplish this can be summarized as follows:

- Intensification of the survey and exploration of energy resources, especially in new areas, and the creation of incentives to attract private investment.

- Diversification to minimize the dependence on oil for domestic use.

- Conservation, by issuing regulations and conducting a conservation campaign to promote more efficient use and saving of energy.

- Indexing certain energy sources for their optimum utilization.

Necessary infrastructure development, such as training, information, investment, research and development, laws and regulations and techno-structure also should be undertaken.

Implementation

Efforts to establish long-range energy planning have been taken. These are based on an estimate of long-range domestic energy consumption and on assumptions of an economic growth rate of between 5.5 and 6.5 percent GDP up to the year 2000, population growth of about 2 percent and an energy elasticity of approximately 1.6 percent during the planning period.

Given these assumptions, estimates for commercial energy demand should reach 934 million barrels of oil equivalent by the end of the period.

At present rates of oil production, total demand would not be covered by domestic production by the end of Repelita V (1994).[5] Consequently, the role of oil in the Indonesian energy mix would decline, while the contribution of natural gas, coal, geothermal and hydro power would increase.

At the rural level, long-term development programs have been consistently formulated and implemented for the purpose of gradually transforming the traditional village into a modern one. Implementation of rural electrification and the development of energy supplies, including locally available new and renewable sources of energy, are an integral part of these programs. Implementation of this strategy is to take place during a 30-year time span, starting with the beginning of the Second Development Plan (1974-1979).

Major energy programs for the 1980-1981 period are being financed by the National Development Fund. These include:

- Mining development (research on processing technology for minerals, oil and gas).

- Geological development (mapping, exploration and drilling for inventory building).

- Electricity development (erection of various power plants, transmission and distribution networks).

- The development of gas and other energy resources (gas distribution networks and surveys on non-conventional energy resources).

- Training and development of physical infrastructure.

In the same budget period, foreign sources of financing equivalent to Rp. 269 billion will be available for the electricity sector, and Rp. 17 billion for rural electrification.

Other major projects in the fields of oil and gas include:

- The construction of a hydrocracker with a processing capacity of 85,000 billion barrels LSWR per day.

- The expansion of two refineries with an additional capacity of 100,000 barrels a day each.

- The construction of a new refinery.

- The expansion of LNG facilities with four additional trains.

- Natural gas utilization projects (as petrochemical feedstocks).

The development of the Bukit Asam coal mine, to produce 3 million tons of coal per year including its infrastructure development, which is to supply a steam power plant for electric generation, is the main project in coal.

Hydro power and geothermal energy development also are targeted for electrical power generation.

Repelita III (Third Development Plan) reflects these energy policy targets. For instance, the role of oil is to decrease from 84 percent to 80 percent, while the aggregate roles of the other energy sources are to increase. The use of non-commercial sources of energy will continue to be considerable, but their relative contribution to the total energy mix declines as their availability decreases and relative inconvenience increases.

On the other hand, energy elasticity is expected to be 1.8 during Repelita III and not less than 1.5 for the balance of this century.

THE ROLE AND POTENTIAL OF NEW AND RENEWABLE SOURCES

Hydro Power

Hydro power already plays a role in electricity generation in Indonesia, and its potential for further development is being evaluated. Hydro potential available for electricity generation has been estimated at 31,000 MW, and the possibilities for small-scale or micro-hydro programs look promising, with some already underway.

The potential for large-scale hydro power plants is restricted by the capital cost per kilowatt, which is relatively high compared to other forms of electricity generation. The development of such plants necessitates technical requirements such as surveys, studies and design of power plants, long-range irrigation plans and soil investigation. Other essential inputs include human and financial resources.

Micro-Hydro Schemes

Faced with many of the same constraints as those encountered by larger plants, the micro-hydro program has made progress, with 27 plants completed and eight plants proposed for the current Five-Year Development Plan. Major constraints include the lack of funds and skilled manpower. Moreover, the very isolation of these areas, compounded by the lack of adequate infrastructure and human resources, contributes to the difficulty of accurate planning. In planning micro-hydro projects, factors such as rainfall intensity and the nature of the catchment area and its elevation require accurate data. Feasibility studies are available for 5,610 villages covering 2.5 million consumers. This only forms part of the whole program.

Nevertheless, micro-hydro power plants could be economical and environmentally viable sources of rural electrification, particularly in regions remote from the main power centers. The development of local industries and technical skills could contribute toward the reduction of cost, and indigenous manufacturing programs for the production of water turbines are designed for the standardization and simplification of units. Transfer of technology is considered necessary to stimulate more progress in the program. In the past, the choice of sites was limited to low head schemes which further increased the cost. The greatest part of the cost is for the procurement of equipment, including the generating unit, which alone accounts for up to 40 percent of the cost of generation.

An indirect benefit of hydro power development is its positive contribution toward water resource management in general, and, in the areas of irrigation and water table maintenance, the control of soil erosion and the promotion of the "greening" scheme.

Geothermal Energy

The potential of geothermal energy has been deductively assessed at between 8,000 and 10,000 MW. The island of Java itself has a potential of about 5,500 MW. In the past six years, experience has shown that a success ratio of .55 has been reached for exploration holes and .67 for production holes. Probable reserves in six development regions have been estimated to be 3,150 MW, with proven reserves of 1,500 MW.

Although the potential of geothermal energy is large and suitable for a dispersed system of energy supply, its present development is directed only toward large-scale applications of 15 MW capacity and larger. Preliminary steps have been taken to investigate the use of this source of energy for purposes other than electricity generation, such as fumigation of the planting base for mushrooms, and crop drying. More precise figures for technically and economically recoverable geothermal reserves and their possible application are not yet available. This also includes possible influences on the environment, especially in densely populated areas.

Solar

Solar energy traditionally has been used extensively in the form of direct radiation. More recently, photovoltaic cells for the generation of electricity are being tested.

Average insolation per year is estimated at about 1,800 KWh per square meter, which is more than the limits of application. Direct solar energy and photovoltaic cells have a role in:

- Crop drying, with and without the addition of hot air storage.

- Solar water heaters and stills.
- Solar cookers.
- Photovoltaic water pumps and refrigerators.

Also, the adoption of solar mirrors for household application has been proposed and tested for economic feasibility. Other efforts have been tried to estimate the potential of photovoltaic cells to generate electricity for very special purposes, such as communication between remote stations and villages.

It is still too early to make any reliable prediction regarding the general feasibility of solar energy for widespread use. Such information will be available only when solar technologies acquire greater maturity and diffusion in the market. Also, socio-economic studies to assess the general acceptance of these projects by the public still have to be evaluated.[6] It is also unlikely that solar energy potential could be fully exploited in densely populated areas such as Java, where land availability per capita is very limited.

Biomass

As a tropical country, the potential for biomass energy supply in Indonesia has been recognized for a long time. Precise data on the economics of biomass energy supply are not yet available. Efforts have been made to demonstrate the potential for energy production as well as for other purposes. Further evaluation still has to be made for activities such as:

- Fast-growing plantations for the dual purpose of regenerating degraded land areas and of fuel wood supply.

- Firewood plantations, with the multiple objectives of reforestation and "greening" for soil erosion control, creating buffer areas surrounding commodity plantations and supply of firewood and food.

These efforts can be enhanced by the development of plant species that make optimal use of the land, and would be commercially and environmentally acceptable.

Firewood plantations were started in 1975 and since then some promising production figures have been obtained. On suitable soils, Caliandra production ranged from 70 to 120 square meters per hectare yearly. Retarded growth has been observed in certain areas, the causes of which are still being investigated. Other species are being tried out as well, although on a more modest scale.[7]

Two extensive programs are underway that would, among other things, renew the energy source of biomass and in particular that of firewood. These are the reforestation program, which is the establishment of new forests on government or public forest land, and the greening program, which is the encouragement of planting perennial species on private and community property.

The annual target is to establish 300,000 hectares of new forest and to "green" 70,000 hectares of critical private land. This accelerated effort created major problems in its implementation. The success rate was initially very limited, at about 50 percent for reforestation and 30 percent for greening.

The greening program is essentially aimed at increasing the vegetative cover of critical land areas to combat erosion and flooding. Free distribution to the community of 15 to 20 firewood species, which are fast-growing perennials with profitable byproducts, has been started. Efforts also have been made to use 10 to 12 percent of the greening program budget for firewood plantation. Up to 1980, 65,810 hectares of land were planted with fast-growing trees. The next step is to create 100,000 hectares of firewood plantations each year, which should yield more than 10 tons per hectare yearly after two years.

These measures should prove helpful in alleviating both the pressures created by an increasing consumption rate and the loss of critical vegetative coverage on hillsides and mountain slopes. However, population pressures too, especially in Java, have encroached on the forests. On the hillsides, clearances are made for the cultivation of such foodstuffs as cassava and other root crops. In these cases, the greening program does not apply.[8]

Waste also could be an important source of biomass energy given the extent of wood and farm production. Timber logs for export alone are estimated at about 30 million cubic meters per year, of which 40 percent is counted as waste. Agricultural waste is extensive because the majority of the population is engaged in farming. Twenty-five million tons per year is derived from rice husks alone. Also 70 to 100 cubic meters per hectare of wood is produced annually from the clearance of wooded land in the implementation of the national transmigration program. Other wastes, such as those from sawmills and plywood factories, which produce roughly 30 million cubic meters of wood residue each year could possibly be utilized as an energy source. A scheme, including the necessary incentives, to convert such waste into energy already has been proposed and in some cases, such as for drying purposes, has been applied.

Biogas

A family-size digester for the production of biogas has been developed and demonstrated since 1978, and an attempt has been made to integrate it into the rural development program. The unit is used not only to provide energy, but also to perform other activities, such as the transformation of residues into fertilizer, cultivation of algae for feeding cattle, breeding fish, and making use of surplus water for irrigating home gardens.

A major constraint hampering its widespread acceptance is psychological -- the use of animal and household wastes for cooking seems unattractive. However, local leaders suggest this barrier may be overcome, at least in the long term. According to studies, a reduction in cost should be accomplished by the utilization of various locally available construction materials.[9]

Another pertinent question is whether this technology would benefit only the relatively well-to-do people and what, if any, effect would it have on the village as a whole.

Wind

Wind power is widely used for the traditional mode of sea transportation. Currently, several locations show promise for land-based generators based on available data. They have wind speeds of more than 20 kilometers per hour and an intensity of more than 1,500 KWh per square meter per hour.[10]

Small-scale applications in rural areas, such as for water pumping and food processing, may be feasible once appropriate data on the availability of wind velocity is collected. Existing data, mostly from the meteorological stations of airports, is not suitable for such decision making.

Some multiblade windmills, which have been installed with foreign aid for water pumping purposes, have not been successful. Improper preparation and maintenance may have contributed to the problem. The main constraints probably are neither technical nor engineering, but rather the lack of capabilities and skills for the preparation of proper feasibility studies and the lack of promotion for local population acceptance. Proper feasibility studies serve to clarify difficult variables, such as the socio-economic interaction of technology and people.[11]

Other Resources

Other potential sources of energy include ocean power (tidal and thermal), peat production, methanol and uranium processing. Energy potential of many tidal basins could be exploited and ocean thermal differentials, in areas of Sumatra, Java and Easter Islands (with shore gradients reaching deeper than 500 meters), have good possibilities as sources of energy. Preliminary investigations indicate if appropriate and inexpensive technology is developed to harness these topographical and hydrographical conditions, several isolated coastal regions could benefit greatly.[12]

Regarding peatland exploitation, preliminary reports[13] estimate that 100 million hectares of such land with an organic content of approximately 30 percent is available, although prospects are not yet evaluated.

Methanol production from sweet potatoes also has been investigated and feasibility studies completed. If this project proves feasible it could be integrated into the transmigration program.[14]

CONCLUSIONS AND RECOMMENDATIONS

Given Indonesia's rich reserves of fossil fuels, and in particular those of hydrocarbons, it is certain that these will continue to play an important and increasing role in supplying the growing domestic demand for energy. Further development of these resources therefore is planned for the purpose of reaching optimal utilization in achieving national development objectives. The development of coal, although its technology is domestically available, is limited by infrastructure constraints and the state's limited development capacity to enlarge it. For the foreseeable future, the development of hydrocarbons will continue to be a priority in Indonesia while new and renewable sources of energy will play a supportive role.

From the Indonesian perspective, the most promising and feasible new and renewable sources of energy are geothermal and hydro power. Both are being developed in Indonesia and may contribute up to 5 percent and 16 percent, respectively, to the generation of electricity by the late 1990s.[15] Biomass, as a source of energy, has been used traditionally, but without proper management it might cause serious environmental problems. Solar and wind energy potentials need further assessment and studies.

Due to the uncertainties and the unproven records of many new and renewable sources of energy as substitutes for hydrocarbons in accelerating national development, and also due to the substantial constraints of human, technological and financial resources, it may be premature to make a definite commitment to their development at this time. However, Indonesia intends to keep this question continuously under review.

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Japan

CONTENTS

TABLES

INTRODUCTION

Japan is most dependent among major industrial nations upon imported energy, especially petroleum, and it is making every effort to ensure a stable supply of energy. To this end, Japan is promoting efforts to secure a stable oil supply and conserve energy, and it is working on research and development related to alternative sources of energy and their actual utilization to meet the current severe situation, both in Japan and internationally.

The importance of developing and introducing alternative energy is widely recognized internationally. In Japan, the government set targets for alternative energy supply reducing dependence on oil to 50 percent by 1990, and began taking the necessary basic measures for increasing development and use of alternative sources of energy. It obtained the necessary budgetary allocations and enacted the "Law Concerning the Promotion of Development and Introduction of Alternative Energy Sources" in 1980, which established the New Energy Development Organization (a private corporation).

It is expected that the bulk of the country's alternative sources of energy will come from nuclear power, coal and LNG, but simultaneously the utilization of other forms of natural energy, such as solar, geothermal, wind, small- to medium-scale hydro power installations, biomass and waste (unutilized) heat or energy from waste material (which have not been utilized thus far) must be increased to partially replace oil. The use of "local energy" (as the above-mentioned alternatives are called in Japan) is essential to a stable energy supply, and a new policy is being worked out to create a system of small-scale and regionally dispersed energy supply for community use.

The state of research and development activities with regard to new and renewable energy is outlined in the following.

JAPAN'S ENERGY SITUATION

Japan's energy supply structure is very vulnerable, with high dependency on imported energy (87 percent in 1979), particularly petroleum (71 percent in 1979). Therefore, securing a stable supply of energy in the severe domestic and international situation is a very important policy matter for the nation.

In the light of the energy situation, the government is endeavoring to ensure a stable energy supply by putting the following measures into practice:

- Securing a stable oil supply.
- Promoting energy-saving measures.
- Developing and introducing alternative energy sources, such as nuclear power, coal, LNG (liquefied natural gas), hydro power, geothermal and solar energy.

In addition to the Law Concerning the Promotion of Development and Introduction of Alternative Energy Sources, the subject of Fiscal Year 1990 supply targets for alternative energy was taken up in a cabinet meeting. The decision of the meeting was that 50 percent (petroleum equivalent: 350 million kiloliters) of the total energy demand should come from alternative energy sources as the basic target of the nation. The individual targets (by source) are as shown below:

Coal	123 million KL
Nuclear power	75.9 million KL
Natural gas	71.1 million KL
Hydro Power	31.9 million KL
Geothermal	7.3 million KL
Others (Solar, liquified coal, etc.)	38.5 million KL

To achieve the goal, efforts are being made in promoting development of alternative energies, such as development of nuclear power, expansion of coal use, promotion of use of LNG, promotion of development and utilization of hydro power and geothermal energy, promotion of solar thermal energy, accelerated development of technology for new energies (such as liquified coal), freeing the power generation industry from dependence on petroleum, fuel changes in various industries and development and utilization of "regional energies".

NEW AND RENEWABLE ENERGY RESEARCH AND DEVELOPMENT

A great deal is expected of nuclear power, coal and LNG. These are areas in which technology already exists to make possible large-scale utilization, and there is considerable utilization of these energy sources. In addition, utilization of natural energy sources and the new and renewable sources of energy, which are seen as local energy, is to be expanded on the basis of locally produced energy to ensure a stable energy supply to each community. These energy sources must be harnessed to the greatest extent possible and utilized efficiently. To accomplish this, the government is striving to establish local energy systems of the small-scale and regionally dispersed type in which community demand and supply are organically linked.

The aims of developing and utilizing local energy systems can be outlined as follows:

Reduction of oil consumption and quantitative expansion of domestically produced energy use: The bulk of such local energy will be natural energy, such as solar, geothermal and wind energy. These are renewable energy sources, which will have practical uses only if the appropriate technology is developed and effective measures are taken to encourage promotion and diffusion of their widespread use.

Improvement of energy supply stability in the community: The exploitation of many local energy sources is not compatible with the operation of large-scale supply systems covering wide areas. However, by planning development and utilization for small units (such as the home, the industrial plant or agriculture and forestry-related facilities) it will be possible to create systems which can adequately fulfill the task of supplying all or part of the energy requirements of the unit served.

Contribution to regional development: Local energy systems are closely linked to the community. By developing and utilizing energy that exists locally, the profitability of local industries and farms can be increased and the creation of new industries, such as tourism, and increased employment opportunities can be expected.

Contribution to local communities: Local energy systems utilize the waste heat from various plants and the waste materials from farming and stock-raising, as well as utilizing clean natural forms of energy, and they can greatly contribute to controlling pollution and assisting waste disposal.

Once such techniques are developed, it will be possible for Japan to provide technical cooperation to developing nations in which local energy is abundantly available.

Problems Regarding Local Energy

The following problems must be solved when developing local energy utilization.

- Initial investment in facilities is great and in many cases it will be some time before the break-even point is reached.
- There is still a considerable amount of development work to be done on techniques and systems for energy harnessing, conversion, storage and transport, and in many areas reliability must be improved.
- People's appreciation of the effectiveness of and need for local energy development and utilization is still inadequate.
- The principal bodies for systematizing the development and utilization of local energy must be established.

Need for Overall Policy

In view of these problems, comprehensive measures must be adopted covering improvement of information systems, promotion of technology development, increasing people's knowledge and acceptance of the local energy concept, and establishing systems and organizations.

Research and Development

Research and development are essential to accelerate development and introduction of alternative energy sources. The "Basic Plan for Energy Research and Development," the "Basic Plan for Nuclear Power Research and Development" and the "New Energy Technological Development Plan" (Sunshine Project) have been prepared for systematic promotion of this research and development.

In the areas of nuclear power and coal, which are expected to account for the main part of the alternative energy, the following are being studied or developed.

Nuclear Power: Further improvement of safety and reliability of nuclear power electricity generation, establishment of nuclear fuel cycle, development of new types of power reactors or multipurpose high-temperature gas furnaces, and nuclear fusion.

Fossil Fuel Energy: Liquefying and gasification of coal, coal-oil fuel mix technology, and similar methods.

Of the energy sources to be discussed in the United Nations Conference on New and Renewable Sources of Energy, Japan is mainly engaged in research and development on the natural energy sources (solar, hydro power, geothermal, oceanic, wind and biomass), with some work being done in other areas. The following outlines the research and development situation in Japan.

Solar Energy: Hot water supply and cooling/heating systems are already in use in households, and research on the utilization of solar energy for industrial purposes is being carried out. Construction of pilot solar thermal and solar photovoltaic generating plants also is being studied.

Hydro Power: Hydro power energy has long played an important role in electricity supply as a purely domestically produced energy. To develop the use of small to medium hydro power plants, technology development is being conducted systematically on water wheel generators of higher performance and civil engineering machines.

Geothermal Energy: Geothermal energy from shallow base rocks already is being utilized. With a view to increased exploitation of geothermal energy, always with particular care being taken to avoid environmental problems, research and development work is being done on exploration and recovery techniques, binary power generation utilizing hot water and power generation systems using hot-rock power generation.

Ocean Energy: Research and development work is being done on wave power generation and power generation using thermal gradients of the sea.

Wind Power Energy: Research and development is being done on wind power generation, the conversion of wind energy to heat and on storage techniques for such heat.

Biomass Energy: Research and development is being done on production techniques for fuel alcohol, on liquefying and gasifying technologies through thermal cracking, and methane fermentation technology. In addition to this, research and development is being done on hydrogen generation energy systems and biochemical cell, utilizing energy plants and photosynthesis mechanisms.

Fuel Wood and Charcoal: Ogalite is a processed fuel substance utilizing waste sawdust developed and widely used as a wood resource. Japanese technology has reached a stage of perfection in charcoal production and makes possible large-scale commercial production and use of this fuel. A charcoal-making technique suitable for unexploited timber resources and agricultural waste is being developed, and the development of pellet fuel, wood-coal tablet fuel and wood-petroleum colloidal fuel is being pushed forward as fast as possible.

Peat and Low Calorie Coal: At present, research and development is being done on low-calorie fluidized bed combustion boilers and large-scale power-generating boilers.

In addition, since about 1978, research and development have been aggressively carried out on coal-oil fuel mix utilization.

There are many subjects to be studied in developing these renewable energies, and in some areas private sector research and development is difficult for such reasons as:

- A relatively long time is required for research and development before practical use.
- Substantial investment is needed for the research and development.
- Excessively great risk is involved in the research and development.

The government takes the initiative in these cases and undertakes the work. In others, the government provides the necessary subsidies. The national budget included the amounts listed in Table 2 for such allocations in fiscal years 1979 and 1980.

GEOTHERMAL ENERGY

In Japan, geothermal energy use has been developed mainly for power generation.

The first commercial installation was the 22 MW geothermal energy power generation plant at Matsukawa in Iwate Prefecture, started in October 1966. To date, six such generating plants have been constructed, with a total output of 162 MW, using thermal energy from comparatively shallow base rocks.

The government has been working on the development and use of alternative energy since the oil supply situation became unstable in 1973, and development of geothermal energy, a domestically available resource, is one of the priority areas. Policies were formulated for the development of geothermal energy for power generation with the targets of 1,000 MW by 1985, 3,500 MW by 1990 and 7,000 MW by 1995. Shallow-base rock surveys are being conducted in many places in Japan to achieve the targets. Concurrently, studies and surveys are being carried out for the development of the utilization of deep-base rock geothermal energy (2,000 meters or deeper).

Because of the character of Japan's geothermal resources, the geothermal resource used for power generation is rarely natural steam alone, being in most cases such steam mixed with hot water. Hot water is a valuable thermal energy source which can be used for multiple purposes, and various plans are being made to use it for regional development.

Research and Development

There are six geothermal energy power generating plants in Japan, with a total output of 162 MW. All of these plants use geothermal energy from comparatively shallow base rocks (1,000 to 2,000 meters). Maximum output at any one plant is 50 MW.

To increase development and utilization of geothermal energy substantially, development of large-scale power generation using deep-base rock thermal energy efficiently is essential.

To promote development for the large-scale use of deep-base rock thermal energy, in addition to the urgent need to establish environmental protection techniques, prospecting techniques applicable to deep-base rock geothermal energy and boring techniques to bore through high-temperature strata must be perfected. The Sunshine Project has been engaging in such research since 1974, and the research and development situation is as outlined below:

Prospecting Techniques: Prospecting techniques applicable to shallow-base rocks have been developed to a great extent. Prospecting techniques applicable to deep-base rocks and on a large scale are being developed.

To develop prospecting techniques applicable to deep-base rock geothermal resources, the prospecting techniques that have been developed so far must be systematized and the establishment of an efficient prospect system and integrated analysis techniques are essential.

Boring Techniques: Boring techniques overcoming the problems of high-temperature conditions are essential to develop deep-base rock boring. At present, techniques using equipment that can withstand the high temperatures (up to 250°C to 300°C) have been perfected and further study is being made to extend their use to 350°C.

Boring bits that can withstand temperatures that may go up as high as 350°C and stratum research techniques for use in such high-temperature conditions must be perfected.

Environmental Protection and Multipurpose Use Techniques: Techniques to remove arsenic contained in the geothermal fluid have almost been perfected. Further study is being made on the removal technique for hydrogen sulfide and on avoiding scaling.

The technical problems involved in removal of hydrogen sulfide and scaling control have been solved, and further study is being made to give improved efficiency and economy in removal operations.

In addition to developing large-scale deep-base rock geothermal energy use techniques, techniques to use the hot water issuing with the steam for power generation, techniques for hot-rock power generation obtaining thermal energy from hot-rocks that do not contain steam and hot water, and hot water supply system techniques using deep-base rock hot water (which is not a volcanic geothermal resource) must be developed. The technical feasibility of hot water power generation has been proved by a pilot plant of the 1 MW class, and further study is being made to enlarge the plant scale and to improve the economic factors. Study of hot-rock power generation is still in the preliminary stage, and research and development work is being done through introduction of advanced techniques in international cooperation.

Economic Appraisal of Geothermal Energy

Geothermal energy power generation involves the following problems:

- Substantial risk during the survey period.
- The size of initial investment required to obtain a given power-generation volume.
- A long period of time is required from investment to profitability.
- There are disadvantages compared to development of other power sources in the initial stages, such as longer lead time from preliminary surveys to operation (although it may be more economically profitable in the long run), and much greater investment required in the initial stage.

Therefore, power generation undertakings utilizing geothermal energy are not advantageous in the initial stage, when compared with other power generation methods. In the case of the geothermal energy power generation plant (50 MW) constructed in 1977, a rough estimate of the construction cost is Y366,000 per kilowatt and the power generation cost is Y12.24 per kilowatt for operation at 80 percent of capacity. The steam used accounts for 61 percent of the cost. Moreover, it is estimated that in the case of a power generation plant of the same scale today, the construction cost would be Y520,000 per kilowatt and the power generation cost Y17.4 per kilowatt, indicating a sharp rise both in the investment amount and production cost.

According to the cost configuration for geothermal power generation, the capital expenditure accounts for 82 percent of the production cost. This is because the fuel cost of other types is replaced by capital expenditure for the steam well and reduction well. In the current situation, in which oil prices are going up constantly, the cost configuration for geothermal power generation as compared with oil-fired power generation looks fairly advantageous in the long term.

HYDRO POWER

In Japan, hydroelectricity accounts for about 20 percent of Japan's generating capacity and for about 14 percent of the power generated. A great deal is expected of its development as a valuable domestically available energy source (see Table 3).

The various types of hydroelectricity generation are classified as follows:

General hydroelectricity	Dam type Dam-channel type Channel type
Lifted water	Lifted water only Mixed lifted water

Because of Japan's topographical character, the channel type accounts for nearly three-quarters of the whole.

With regard to hydroelectricity generated by methods other than the lifted water method, most of the power stations to be developed in the future are of small to medium scale and it is estimated that 90 percent of newly developed plants will be of the same scale (output 50,000 KW or less).

Hydroelectric generation on a small to medium scale has been highly praised as a local energy possibility. It is generated close to the consuming communities and the role played by prefectural and local governments will be important. On the other hand, to promote development of small- to medium-scale hydroelectric generation, the government has established a subsidy system (available for plants of 50,000 KW or less) in 1980 to help with the construction cost.

Although nuclear and coal-fired generation will be the principal substitutes for oil-fired power generation, still the basic power source, lifted water power generation can help satisfy demand at peak times, and it is expected to play a significant role in Japanese policies for getting away from dependence on oil.

Problems of Hydroelectricity Development

While the long-term running cost is fairly stable, owing to the nature of hydroelectric generation, development of hydroelectricity requires a large investment in the initial stage. This cost makes development of hydroelectricity rather expensive in its first stages. The number of places where economically advantageous development is possible has been decreasing, too. Therefore, subsidies or similar financing systems to assist entrepreneurs engaging in the development of hydroelectricity must be strengthened to encourage its development.

To promote hydroelectricity development, Japan's hydroelectricity potential must be accurately assessed and development guidelines based on such data must be clearly provided. For this purpose, in addition to places that already have been recognized as suitable, it is necessary to draw up plans for development of more locations for hydroelectricity development, including redevelopment, small- to medium-scale hydroelectricity generation, low head drop, or overall development, based on evaluation standards in keeping with existing social and economic circumstances.

In order to increase the number of small- to medium-scale hydroelectricity generation plants, which are not economically advantageous, the cost of the related machinery and other factors must be lowered.

To do this, technology development and demonstration tests related to water wheels, generators and civil engineering machinery must be pushed forward aggressively.

If it is to be made easier to obtain sites for hydroelectric generation plants, it will be necessary to obtain the full understanding of the local people with regard to environmental protection. This makes it even more important to enforce the environmental protection policies that already have been put into practice.

Research and Development

To promote development of small- to medium-scale hydroelectricity generation, which is not economically advantageous, the technology developments shown below are now going on or are under consideration, aiming at cost reduction (research and development is scheduled for completion by the end of Fiscal Year 1983):

- Development of a new type of water wheel for use in power generation in super-low head drop areas (3 to 20 meters). Development of a new type water wheel for use in power generation with little water flow or medium head drop areas (20 to 100 meters). Research and development work on a high-performance water wheel applicable to low loads for power generation in high head drop areas (100 to 300 meters) and the like.

- Standardization and simplification of facilities related to water wheels and civil engineering structures.

- Research and development work on tunnel-boring machines for all geological features and sections (for hydro power tunnels).

To avoid reduction of the power generation potential due to alluvion in power-generating reservoirs, systems for effective use of such soil must be developed.

For some time, research has been carried out on the feasibility of generating electricity using lifted sea water. Development of such techniques should be prompted further. Such techniques actually will be used after experimental tests on environmental problems.

SOLAR ENERGY

Solar energy use is of three types: solar thermal generation, photovoltaic generation and solar cooling/heating, and hot water supply systems.

With regard to solar thermal generation, a pilot plant is being constructed and there is no commercial utilization. It is expected that the technical and economic points regarding utilization will become clear in operation of the pilot plant.

Use of solar photovoltaic generation techniques has been limited to special power units, such as for unmanned lighthouses, radio relay stations in remote areas and satellites. There is no general use in houses, buildings or factories. There are two major reasons for this.

First, the price of solar cells is extremely high (several thousand yen per watt) and the power generation cost makes this form of generation uncompetitive.

Second, no system has been established which will make possible the utilization of solar photovoltaic electricity for general use.

Accordingly, technology to reduce the cost of solar cells and technology to establish systems utilizing solar cells must be developed.

With regard to solar houses, the technology is almost perfected and there is some actual utilization. Nevertheless, there are still some problems, such as the high initial cost resulting in the need for a comparatively long period of time before profitability (savings) is achieved, and need in some areas for improved performance or reliability. Measures centering on support for the diffusion and promotion of the solar house are needed in addition to technology development for improvement of performance and reliability and reduction of cost.

	Installation
Single house	14,174
Apartment house	50
Welfare and work purposes	899
Industrial use	50
(Public use)	249
Total	15,173
(including 249 of public use)	

	Installation
Hot water supply	14,458
Hot water supply and heating	506
Hot water supply and heating/cooling	170
Others	39
Total	15,173
(Survey period: from 1975 to June 1980)	

Research and Development

For research and development work on solar thermal power generation, two pilot plants of 1,000 KW are being constructed, one using the curved-surface beam collecting method. Completion of the plants is scheduled for March 1981. They will be operated for studies for two or three years after a trial operation period lasting about six months. High cost is anticipated for solar thermal power generation, and to overcome this problem, research and development work on a technology and a system to utilize solar heat directly already are being pushed forward, in addition to research on techniques to reduce the size of the component parts, and improve system efficiency and utilization of heat conversion into electricity. It is expected that the operation of the pilot plants will identify some of the problems which need to be studied.

On the basis of the problems outlined, research and development work is in progress, with the emphasis on reducing the price of solar cells and establishing systems using solar cells.

The following efforts have been made to reduce the price of solar cells:

- Research and development work to develop technology which will make possible the production of silicon, the main material used in solar cells, in mass-production volume and reduce the cost to the lowest possible level.

- Research and development of the technology needed to produce solar cell panels at the lowest possible cost using the continuous and mass-production system.

- Development of new solar cells, such as compound semi-conductor solar cells.

- Research and development work on amorphous substance solar cells aiming at drastic reduction of the cost of solar cells in the future.

The following efforts have been made to develop systems using solar cells:

- Development of demonstration solar photovoltaic power generation systems installed in houses, buildings and factories equipped with solar cells.

- Research and development work to establish a solar photovoltaic power generation system of the centralized power generation plant type.

In the area of solar energy cooling/heating and hot water supply systems, since 1974 a great deal of work has been done on four systems: systems for existing private houses, systems for newly built private houses, systems for apartment blocks and systems for large buildings. At the same time, development work on the materials used in the system components has been done and the technology has almost been perfected. A number of solar houses have been built in the private sector utilizing the results of this research. However, as pointed out, there still exist some problems.

In the area of solar systems for industrial use, there are many problems that have not yet been solved technically, and at present such systems are used mainly for air conditioning or preheating of plant buildings. Development of the technology needed to complete a solar system that can be used in industry, where complex and (high-level) thermal control is required has started.

WIND ENERGY

In Japan, utilization of wind energy was studied in the "Futopia" project of the Science and Technology Agency ("Fu" being derived from the Japanese word for wind), during 1978 to 1979, using eight small windmills of the 1 to 2 KW class. The experiment was concerned mainly with the utilization of wind energy, and some data was obtained on developing small windmills for practical use.

Wind energy utilization also has been studied using large windmills, as indicated below:

- Thermal windmills, especially windmills (operation started in 1980) for plant cultivation in greenhouses, having a daily calorific output of 450,000 kcal.

- Windmills (operation to be started in 1982), having an output capacity of 100 KW, for electricity generation.

Experiments have been conducted on a total of eight windmills, three in Kanazawa City, Ishikawa Pref., with a rated output of 1.5 KW, 1 KW and 2.2 KW; two in Annaka City, Gunma Pref., with a rated output of 1 KW and 1.2 KW; two in Taketoyo City, Aichi Pref., with a rated output of .75 KW and 1 KW; and one for water-lifting.

Energy generated from the Kanazawa City facility has been used for heating fish tank water and electricity for insect-lure lamps. The Annaka City facility has been used for charging golf carts and electric cars. The Taketoyo City facility has cooled and heated a miniature greenhouse and has been used for water-lifting.

In the case of a 10 square meter greenhouse in Taketoyo City, two windmills supplied electricity equivalent to 28.6 percent of the total power consumed for heating, and 40.9 percent of that required for cooling.

In the case of charging golf carts in Annaka City, the two installations were able to charge .5 12-volt carts per day and .5 24-volt carts per day. However, since 54.9 percent of the power generated was not used in order to avoid overcharge of the golf carts, the possible performance of the installations may be considered to be twice the above. The electric car (24 volt) ran an average 7.4 kilometers per day with charging using both wind and commercial electricity. Charged using one windmill, it could run for 3 kilometers (making the ratio for running on wind power charging 40.7 percent). During a period when there was quite a lot of wind, in the early part of February 1980, the distance run on wind power reached 6.7 kilometers.

In Kanazawa City, the percentage of the electricity supplied by the three windmills for the heating of the fish tanks and the insect-lure lamps was 1.5 percent of the total required for those purposes. Possible reasons for this particularly low ratio could be low average wind speed where the windmills were installed and the fact that the windmills were not large-scale electricity generating types. Another factor was that inadequate wind stopped the windmills frequently, causing the batteries to run down frequently.

The amount of water lifted (10 meter lift) in Taketoyo City was 128.5 liters per day per windmill.

Wind Power System for Greenhouse Cultivation

The Agriculture Department of Shimane University (Matsue City, Shimane Pref.) began experimental cultivation of vegetables and flowers in a solar system on the farm attached to the university from May 1978, and has succeeded in reducing oil consumption to 50 percent of the amount used before conversion to solar heat (using a solar heat collector of 340 square meters). However, because in the part of the Japanese mainland facing the Japan Sea where Matsue is situated sunshine hours are very short in winter, solar heat alone would not achieve adequate results. The department intends to utilize the seasonal winds peculiar to the district in addition to solar heat. For the first time in Japan, operation of a wind power electricity plant (450,000 kcal per day; windmill of 22 KW class when converted for power generation), consisting of a combined solar system and a wind power system, started in March 1981.

In winter, owing to lack of sunshine, the solar system alone cannot provide enough heat for plant cultivation in the greenhouses. A wind system is combined with the solar system to warm water to 50°C to 60°C which is used for heating by circulating it through the greenhouses until the water temperature drops to 20°C. An experiment involving the cultivation of 7,000 tomato plants in two greenhouses with a total area of 800 square meters is planned.

Wind-Powered Electricity Generation of 100 KW Output

The Agency of Industrial Science and Technology, Ministry of International Trade and Industry, is developing a wind-powered electricity generator of 100 KW output as part of the Sunshine Project. The construction of the facility will begin in the early part of Fiscal Year 1981, and operation is scheduled to begin in the latter part of Fiscal Year 1982. The generator will be installed on Miyakejima in the Izu Islands, where the electricity generation cost is higher than on the mainland.

OCEAN ENERGY

In Japan, studies on the utilization of ocean energy have been focused mainly on wave power generation studies and ocean thermal energy conversion studies. In addition, studies on the use of ocean currents to generate power are now underway.

Wave Power Generation

Because of its nature, wave power generation can best be utilized as a power source in areas, such as remote islands, where the supply of power from the existing power line networks is inadequate. This form of power can be used to supplement supply at peak-load times, or in combination with other systems.

For wave power generation to become a viable alternative energy source in the future, it must be made economically competitive with other sources of energy. To achieve this, it must be generated on a large enough scale. The research and development targets for completion by 1990 are as follows.

- A large-scale wave generation system using an air turbine method. Development of the "Kaimei" system (a ship-shaped buoy) to give a more efficient and larger system. (The present Kaimei is a floating wave-power system of the 30 MW class.)

- Development of a wave power generator of the floating breakwater type.

- Development of a wave power generator of the stationary caisson type.

- Development of a wave-current power generator.

- Development of other methods.

The Marine Exploitation Technology Center began research and development for a large-scale wave-power air turbine generating system in 1976, and the study is still in progress as a joint research project with the International Energy Agency. This system consists of eight power generators installed on the Kaimei floating off Yura, a town in Yamagata Prefecture. A second marine experiment using the Kaimei was conducted from September 1979 through March 1980, and a total 67,000 KWh of power was generated, part of which was actually consumed by houses in the area.

In the future, it will be possible to utilize this type of system for supply of electricity for general purposes by developing larger and more efficient Kaimei generators and hydrogen production of extraction of the uranium and lithium present in sea water in parallel with power generation in sea areas where the wave energy is greater.

To accomplish the above, research and development on the following are essential:

- Development of a low-pressure air turbine with a unit volume of 5,000 KW.

- Development of systems giving improved efficiency of electric generation (controlling the number of units).

- Development of systems giving more regular air supply and technology to give constant power generation levels and improved storage of the power generated.

- Development of technology needed for transmission to shore.

Regarding the economic feasibility of wave power generation using the air turbine system, detailed data is now being analyzed, and it will be reviewed after the final results of the analysis.

Small-scale wave power generators have been used as power sources for channel-marking buoys. During the past 15 years, 1,000 units have been in use. The unit has a power generating capacity of 60 watts, but is being used for a 10 watt load on the average.

Ocean Thermal Energy Conversion

Ocean thermal energy conversion is a power generation method utilizing the difference in sea water temperature. The difference in temperature is utilized to evaporate low-boiling-point gases, such as ammonia and freon gas, on the surface water, and to condense it at deeper levels of the sea. The change in pressure activates the turbine, which generates power. Because the temperature difference is not great (about 20°C), to attain a system that is both economically viable and gives effective power generation, new technology must be developed. To accomplish this, a number of plans have been formulated.

A 1 MW pilot plant will be built in 1982 to carry out a power generation feasibility study and solve the engineering problems involved in a larger-scale version, and to ascertain the design requirements.

A 10 MW demonstration plant, which is to be constructed based on the results of the above feasibility study, will undergo technological evaluation beginning in 1986. There will be detailed evaluation of its technical and economic viability to obtain data for the actual siting of such plants.

Based on the results of the above, a full-scale plant of the 100 MW class is to be built by the early 1990s. The research and development situation regarding these plans is outlined below.

The Agency of Industrial Science and Technology (Ministry of International Trade and Industry) has been conducting research on power generation utilizing the thermal gradient of the sea since 1974 as part of the Sunshine Project. As a result of studying conceptual designs and cost factors of a commercial plant of the 100 MW class, it is of the opinion that such a plant is feasible. However, there are many technical problems to be solved before power generation utilizing the thermal gradient of the sea will be in practical use.

The Tokyo Electric Power Engineering Co., in collaboration with the Tokyo Electric Power Co., drew up plans for construction of a 10 KW pilot plant for ocean thermal energy conversion on Nauru Island (Republic of Nauru) as an experiment to study the feasibility of building a full-scale commercial plant in the future. The Nauru government approved the plan in 1979, and the company carried out surveys concerning weather, sea conditions and topography in November of the same year. The pilot plant's design specifications were determined on the basis of the results of the survey.

It is assumed that the heat exchanger of the evaporator and the condenser in the system will affect the power generation cost substantially, and that they will account for 30 to 50 percent of the total construction cost. The choice of heat exchanger is the most decisive factor affecting efficiency in ocean thermal energy conversion. The Tokyo Electric Power Engineering Co. decided to install the plate and shell type in view of the greater ease with which it can be transported and installed, and its maintenance and economy. Fiber-reinforced plastic pipe was used for the cool sea water inlet in view of the oceanic environment in the South Pacific, speed of laying of pipes, and because of the impossibility of checking and repairing at the great depths involved.

Although the plant is a pilot one of the 100 KW class, in order to generate that amount of electricity with a temperature difference of about 20°C, a large amount of sea water must be sucked in at both high and low temperature sources, which necessitates the use of a large pump with a large power consumption, thereby reducing the net output. Also, because the pump's efficiency is affected by the fluid's resistance in the pipeline, resistance resulting from length of inlet pipe, pipe diameter, coarseness of the inner face and various equipment attached to the pipeline must be carefully reviewed during design.

If this plant is designed similar to a conventional thermal power station, while giving consideration to the pilot plant's special characteristics and construction cost, it would be possible to obtain a net output of 25 KW from a generation terminal output of 100 KW, utilizing a temperature difference of

23.8°C (29.8°C and 6°C). However, the present pilot plant is being designed to give a net output of 10 KW, because of construction cost considerations. This will give a generation cost per kilowatt/hour of Y1,000 to Y2,000, which is very high. Tokyo Electric Power Engineering Co. is planning to develop, based on the results of the above-mentioned experimental plant, commercial plants using generators with an output capacity of 2.5 MW. Eventually four of these generators will be installed, to give a total of 10 MW. The target cost for such a plant is between Y150 and Y200 per kilowatt/hour.

Ocean Current Power Generation

In Japan, various prototypes of generators are being built and operated in pilot plants. Based on the results of these experiments, generators will be built to produce 1 MW to 5 MW, using sea currents of medium to high speed at a mooring depth of about 50 to 100 meters. The power generated is to be transmitted a short distance, to a nearby island. Also, a plant of medium size (5 MW to 10 MW) will be constructed.

To harness the Kuroshio current's kinetic energy to produce electricity, a stabilized stream axis and a high current speed are essential. Also, to determine the probable amount of electricity that can be obtained from Kuroshio kinetic energy, a current speed-duration curve must be prepared as basic data for assessing the probable magnitude of the speed of the current and its stability.

The amount of kinetic energy contained in the Kuroshio is assumed to be equivalent to 170,000 million KWh per year. Trial calculations indicate that the amount of kinetic energy contained in an area with a flow rate of 1 meter per second or faster would be 90,000 million KWh per year. The four areas involved (around Yaeyama Islands and other islands) have an average depth of about 200 meters, which should make it comparatively easy to harness the fairly constant kinetic energy. The average kinetic energy in these areas is equivalent to 7,000 million KWh (an average electricity-generating potential of 800 MW per year).

The following ocean current electricity generation techniques also are being studied: the propeller mooring method, the propeller stationary method, the Savonius rotor method, the all-current direction-longitudinal axis method, the sail canopy method and the electromagnetic method.

Of these, research and development work will be done on the propeller mooring method and the Savonius method. Work on the electromagnetic method utilizing super-electromagnetic force will be begun as soon as the necessary data on peripheral techniques is available. At present, tests and studies are being conducted on the Savonius rotor method using water tanks towed over the ocean surface.

PEAT AND LOW CALORIFIC COALS

Use of low calorific coals as fuels started in Japan in 1953. In the early 1970s, development of the fluidized bed combustion boiler for burning low calorific coals was started. As a result, a small commercial fluidized bed boiler was constructed in Hokkaido in April 1980, and is now in operation.

Development of a large-scale fluidized bed combustion boiler for power generation is also underway.

In addition, from 1978 an intensive research and development effort has been promoted for the utilization of coal-oil mixture as one of the utilization technologies to be developed. This is considered to be an effective means of utilizing low calorific coals.

Fourteen boilers utilizing low calorific coals have been installed, most of them corner fired with direct-fired milling systems.

One plant is a 150 MW thermal plant (75 MW x 2) burning low calorific coal of less than 3,000 kcal per kilogram. We have calculated that the cost of generating electricity with such a power plant would be Y14 to Y15 per kilowatt hour.

Fluidized bed combustion has long been studied and used in incinerators for municipal sewage sludge, power station waste (oil ash, shells, sludges) and industrial waste. It has also been used in fluidized bed ore roasters, for municipal refuse/pyrolysis, and in coal gasification reactors.

With such experience as a background, a fluidized bed combustion boiler producing 10 tons of steam per hour was put into operation in April 1980. It burns sludge coal recovered from the waste water treatment used in the coal preparation process, and is the first commercial installation of this kind in the world. The sludge has a calorific value of 3,000 kcal per kilogram and contains 58 percent ash and 30 percent total moisture. When wet, it has a calorific value of only 2,200 kcal per kilogram and is of such low quality that it is almost impossible to burn in a system employing conventional combustion technology. The boiler is located in a coal-producing area where temperatures are low. It will contribute directly to reducing the huge amounts of money such an area spends on heating during winter months. The benefit is even greater because the fuel itself has, up to now, been unusable. The economics, when this retrofit boiler is a remodeled heavy-oil burning boiler, show a savings of 2,400 kiloliters per year of C-oil for heating in winter can be expected using 14,000 tons of sludge per year. Assuming Y50,000 to Y60,000 per kiloliter as the price of heavy oil, the remodeling cost can be depreciated in two years, and the unit price per 1,000 kcal is estimated to be Y3 to Y5. If it is assumed to be a new installation, the figure will be more -- Y6 to Y10 per 1,000 kcal.

As a step to demonstrate the advantages of fluidized bed combustion, a 20 t/h pilot plant is being designed and constructed. The purpose of this pilot plant is to investigate and demonstrate the possibility of fluidized combustion being applied to large utility boilers. It is hoped to demonstrate better environmental characteristics, less waste, controllability, reliability and versatility in the use of different types of coal. The detailed design was completed in FY 1979. Construction will be completed by the end of FY 1980, to be followed by commissioning and operation in FY 1981 and thereafter. Conceptual design of a 500 MW coal-fired fluidized bed combustion power generating plant boiler was carried out, using experimental data for combustion characteristics, heat transfer, erosion and corrosion of tubes and sulfur retention efficiency. This conceptual design work was sponsored by the Coal Mining Research Center in Fiscal Year 1978. Although the cost differences between the two types of boiler are relatively small, the fluidized bed combustion boiler is more advantageous because it is possible to eliminate both the stack gas scrubber and de-Nox system, resulting in lower electricity generation costs. Elimination of the stack gas scrubber alone indicates the possible advantages of fluidized bed combustion.

Coal-Oil Mixture

Mixing coal and oil to produce a liquid fuel is considered one of the promising new coal utilization technologies. This technology involves mixing pulverized coal with oil in proportions of about 50 percent by weight to make a homogeneous and stable liquid-type fuel known as coal-oil mixture. The salient features are that it can be treated like a liquid fuel and has the following advantages over solid fuel:

- It can be used in existing installations designed to burn crude or heavy oil after only partial modification.
- Transportation by sea becomes easier.
- Port loading and storing facilities can be simplified.
- Capital investment and operating cost reductions are possible, compared with the pulverized fuel boiler.

Furthermore, the utilization of such low-grade coals as sub-bituminous and brown coal, which have so far been disregarded as boiler fuel, is possible.

Considering the economics of the mixture when used in new utility power stations, blast furnaces in steel plants, rotary kilns for the cement industry and industrial boilers, we have come to the conclusion that assuming a coal cost of Y10,000 per ton and other conditions, it can be more economically advantageous than fuel oil, if the cost of oil is Y34,000 to Y42,000 per ton or more.

Development has been taking place in various areas of coal-oil mixture technology, such as technology related to utility boilers, blast furnaces and industrial boilers, and is being intensively pursued in each area.

Let us take, as an example, the present status of the development of the mixture for power generation use. The Electric Power Development Co. (EPDC) is planning a two-stage demonstration program burning the mixture in a power plant. In the first stage, two burners out of 25 in a 250 MW pulverized fuel boiler have been converted to coal-oil mixture, and a 10-ton per hour manufacturing plant was installed in 1980. Combustion tests began in January 1981, lasting for about one year. Following the tests, the capacity of the manufacturing plant will be increased to 200 tons per hour, and a 350 MW oil-fired boiler will be converted to 100 percent mixture firing. The use of coal-oil mixture in this boiler is expected to begin in FY 1983.

BIOMASS ENERGY

Fuel Alcohol

In Japan, alcohol is made from coarse alcohol, molasses, juice dross molasses, sweet potatoes and maize. It is used for industrial and beverage purposes. At present, alcohol is not used as fuel, either mixed with gasoline or alone.

Much attention is being paid to fuel alcohol as an alternative energy source, and tests and studies are being made on alcohol mixed with gasoline as automobile fuel, with the economic factors, storage qualities and environmental effects of the exhaust gases being studied.

Technology development toward more efficient mass production and lower cost conversion of alcohol, and the securing of a large and stable quantity of inexpensive raw material, is essential if alcohol is to be an effective energy source on a large scale.

Studies are being carried out on alcohol production at high temperatures, and on high-concentration fermentation using sweet potatoes and molasses, both of which are conventional materials for the production of alcohol in the batch fermentation process. Also, the production of alcohol from cellulose, such as straw and bagasse, and a new project involving the very efficient alcohol continuous fermentation technique (which obtains alcohol from starch using fixed yeast) are being developed with government support. In addition, the development of an energy-saving production technique for fuel alcohol is scheduled for the future.

The breeding of new types of potatoes containing more starch and able to be grown in larger quantities for use as raw material is being attempted.

No conclusion has been reached yet on the potential of alcohol mixed with gasoline, and it is still under investigation. The fuel use of alcohol should not be limited merely to mixing it with gasoline. Studies must be carried out on the use of alcohol as a substitute of medium refined products, such as kerosene and diesel oil.

The cost of alcohol as an energy source has not been completely determined yet. It depends greatly upon the price of the raw materials used. Because the cost of manufacturing alcohol also depends on the production scale of the factory involved and the amount of the investment in production facilities, we are working on the development of a technique for producing alcohol from cellulose materials in parallel with research on the amount of the relevant biomass available, feasibility of use as fuel, and the economics, as a feasibility survey of a total system for alcohol production and use which includes determination of optimum plant size.

In any event, alcohol is regarded as a most promising alternative energy. It is believed that fuel alcohol will become strongly competitive as petroleum prices increase in the future.

Methane

In the past, the use of methane as fuel obtained from animal waste was fairly widespread. Small-size fermentation tanks for this purpose were developed. However, methane later was replaced by less expensive and easier-to-handle fuels, such as propane. In factories, the methane fermentation technique was used to process waste water, but use of the technique did not expand. Methane fermentation alone could not satisfy the water quality control regulations as they became stricter.

However, due to recent increases in energy costs, the methane fermentation technique in agriculture and in industrial production is being reevaluated from the standpoint of saving energy. There are many large-scale fermentation tanks (capacity 1,000 to 5,000 cubic meters) being used for producing methane for consumption within plants engaged in activities such as alcohol production, yeast production and sewage processing.

In addition, the use of methane is being studied for the purpose of attaining effective use of this potential energy source by stock-raising farmers, agricultural associations, pulp plants and foodstuff plants.

Much research and development work has been done on the methane fermentation technique in recent years. The technique is promising and important in the context of the current energy situation, and the environmental problem of the wastes from agriculture, forestry, fisheries, cities and factories. Wastes from these sources traditionally have been disposed of by processing with the activated sludge method, which is expensive both in terms of money and manpower. Development of an adequate methane fermentation technique will accomplish two purposes at the same time: waste disposal and energy production. It promises to be a cheap method of waste disposal and produce a new source of energy.

Wastes (animal excreta, waste vegetables, tangerines, waste from starch, fish and meat processing plants, activated sludge from sewage-processing plants and city garbage) will be used.

Fermentation facilities to process waste from agriculture, or stock raising and foodstuff processing plants, are usually small in scale. Various systems for processing excreta from swineries breeding 10 to 500 pigs have been studied. In certain cases, enough progress has been made for them to be used in pilot plants.

Systems for methane fermentation of activated sludge in sewage and city garbage are larger in scale, and there are several good-sized systems already in operation. Technology for the production of methane efficiently from city garbage has advanced to the stage when pilot plants using this technology can be built.

Technology is being developed to use methane from stock raising waste to heat water used for cleaning animals and animal houses, energy for the air conditioning of animal houses and for operating milkers. In the case of large-scale plants, such as sewage processing plants, enough electricity can be generated to operate the facilities in the plant.

In Japan, because the temperature drops below 10°C in winter, research has been done on ways of keeping the fermentation vessels at an appropriate temperature for efficient methane production using solar heat, generated heat of the underwater stirring pump and by burning a part of the methane generated. The use of fermentation residues as fertilizer also has been studied.

It is conceivable that methane gas could take the place of city gas, in addition to its use in generating electricity and as a raw material for the chemical industry. Given the obvious advantages, the system for supplying materials, production and utilization of the gas must be studied thoroughly as a total system.

Heat Cracking

Heat cracking gasification techniques for wood and charcoal were developed during World War II, and at that time the majority of automobiles in Japan ran on charcoal gas. After the war, as the petroleum supply recovered, charcoal-burning cars disappeared and the gasification techniques have not been developed beyond that point.

The scale of livestock raising has increased in recent years, and how to dispose of the animal waste has become a serious problem. Recently, a technique was developed at large swineries for processing pig excreta into pellets, and then gasifying these pellets using the heat cracking method. This technique already is being put to practical use as a means of solving the disposal problem and to effectively conserve energy and promote the use of new forms of energy.

At present, the gas-producing technique using heat cracking of chaff is being developed. It is estimated that this technique will produce more energy than is needed for drying unhulled rice at rice centers. Basic studies are being carried out on gasifying or liquefying city garbage using heat cracking, with experiments using paper and wood.

In the past, a technique for gasifying wood and charcoal was used. At present, basic studies are being made to discover a more efficient gasifying technique.

Direct Combustion

Chaff incinerators are in practical use. The heat generated is being used for drying unhulled rice in rice centers (unhulled rice drying and rice cleaning facilities) and for heating greenhouses.

Chaff incinerators are at the stage of actual use, but further studies are being made to improve the furnaces to give more efficient combustion and to reduce their size. Also, the technique for producing a solid-type fuel by compressing rice straw and wood waste into pellets using high temperatures and pressure has advanced to the stage of constructing a test plant (processing capacity 100 kilograms per day) for actual use.

The economic advantages of the technique can be evaluated by operating this plant. It is expected that the plant will prove to be profitable utilizing unused wood waste resources.

Compound Analysis

Basic studies are being carried out on hydrocarbon analysis and compound analysis using Eurphorbiales and eucalyptus plants. Experiments to find the most suitable compounds and on the large-scale cultivation possibilities of these very useful plants are being carried out.

Hydrogen Fuel

Studies are being made to generate hydrogen from water by means of plant photosynthesis, and research is being carried out on organic solar cells, but the study of plant photosynthesis is still at its basic stage.

FUEL WOOD AND CHARCOAL

Of Japan's total land area, 68 percent is wooded. Wood and charcoal have for centuries been used as fuel. To ensure a steady supply of timber, an area is replanted after felling. In 1951, wood and charcoal were used for 75 percent of household fuel requirements, but at present they have been replaced by kerosene, city gas, propane gas and electricity. Households now use wood and charcoal for only .3 percent of their fuel requirements. Production has dropped to less than 1 percent for wood for use as fuel and less than 2 percent for charcoal, as compared with 1950, when production was at its peak. The share of wood used as fuel in Japan's total timber production was about 25 percent in 1960, but is now only 1 percent. Production of ogalite has declined owing to falling demand and a shortage of raw materials. However, due to the worsening oil situation, the demand for these types of fuel started to increase from June 1976, with charcoal showing a remarkable increase in demand. Also, the recent switch from heavy oil-burning boilers to wood waste-burning boilers is taking place increasingly in the plywood and timber industries.

Both wood-type fuel and ogalite have been used for heating and cooking and for baths, but because they generate smoke, the furnaces must be equipped with adequate ventilating equipment. Therefore, fuels of these types were used mainly in villages and they are not suitable as fuel in an urban environment.

There are two types of wood fuel. One is ordinary wood the other is wood left over at sawmills, which is mainly scrap wood. Both are used as fuel in areas close to the production sites, with transportation accounting for only a small part of the price.

There is steady demand for ogalite as fuel in houses in mountain or farming areas, because the price per calorie is lower than that of other fuels, such as kerosene. Ogalite also is used instead of charcoal. Sawdust, the raw material from which ogalite is made, recently has become scarce because it is used in litters in livestock houses, in the cultivation of mushrooms, as feed for livestock and as a heating resource in sawmills.

The demand for ogalite as a heating resource in greenhouses is increasing, in addition to its conventional use as a fuel for homes and as one of the means of replacing petroleum and conserving energy. For all these reasons, development and improvement of equipment (such as crushers and moulders for the production of ogalite from tree bark), or development of heaters to burn this type of material to heat houses or greenhouses, is expected to increase markedly.

Charcoal produced in Japan can be divided into two types, depending on how it is made -- white charcoal and black charcoal.

White charcoal gets its name from the fact that it has a fine covering of white ash over it because it is raked from the oven while still red hot and covered with a white ash to extinguish the fire. White charcoal has a higher specific gravity, is harder and burns longer. Because of this, it is used for grilling meat or fish and in the tea ceremony. As a result of the resurgence of interest in traditional cultural pursuits and an increasing demand for more elaborately prepared foods, the demand for white charcoal has been increasing.

Black charcoal, which can be lighted quickly and produces greater heat, is used mostly as a household fuel. However, because heaters to burn this type of fuel in today's houses have not been adequately developed and its price is rather high, demand for black charcoal is decreasing.

Charcoal still has a role as an emergency fuel for use after earthquakes.

Much is expected of charcoal as a soil improvement agent in agriculture and forestry, in addition to its traditional use as fuel for homes and industries.

On the other hand, the areas where the charcoal-making material is available are decreasing and one has to go deeper and deeper into the mountains to obtain it. The average age of charcoal burners is increasing. Recruiting and training younger workers and expansion of the production technique are very urgent matters where the possibilities of this fuel are concerned.

Research and Development

The principal emphasis in the area of research and development of wood-type fuels has been on charcoal production techniques.

Charcoal mainly has been produced in kilns, which can be divided into white charcoal kilns and black charcoal kilns. The black charcoal kilns are mostly built of clay, but the white charcoal kilns are built of bricks and stone. They have greater refractory performance, and the internal temperature goes up to 1,000°C or higher. Each district has its own kiln-building technique and it can be said that Japan's charcoal producing technique is quite advanced.

In addition to work on normal charcoal production methods, there is felt to be a pressing need to develop simplified charcoal-producing techniques suitable for leftover forest wood, scrap wood, bamboo or waste from agriculture. Accordingly, the main subjects for research and development related to charcoal are carbonization using mobile carbonization kilns for scrap wood and to the use of this charcoal for purposes other than the traditional use as fuel. The National Forestry and Forest Products Research Institute has perfected a mobile carbonization furnace and it is being widely used. In addition, the institute is studying charcoal production using a rotary kiln, which is one of the factory-scale charcoal production systems, and a charcoal production method using a square-block kiln developed by the institute. The square-block kiln is advantageous because it is easy to build, only a short time is required for making charcoal, yield is high and quality good.

Ogalite is a processed fuel developed in Japan. Sawdust is dried until it contains only about 10 percent moisture, and then it is pressurized, quickly burnt and molded. It can be made by machines which are comparatively small in power (10 to 25 horsepower). Ogalite has a greater specific gravity (about 1.2) and because it is very dry it is superior in performance, having a much higher calorific value than ordinary wood used as fuel. One of ogalite's weak points is that it has low resistance to humidity, and this is an important area for further study and development.

Other possibilities being studied are pellet fuel, wood-coal tablet fuel and wood-petroleum colloidal fuel.

It can be said that almost no reevaluation work has been done on techniques to utilize wood-type fuel in the past 20 years. Setting aside the price factor, the major reasons wood-type fuel and charcoal were replaced by other fuels would seem to be the inadequacies of the burning equipment.

The repeated oil crises of recent years prompted a revival of interest in these types of fuel, and a great deal of development is being carried out to improve stoves and hot water boilers for heating and hot water supply for houses and heating equipment for greenhouses. Utilization of wood-type fuel (plant waste) in boilers, for example in wood-processing plants and in the timber industry, is becoming very popular. Various types of equipment have been developed, and the heating efficiency of some of them is very high.

Development work is being done on systems in which combustion energy is used directly as processing energy instead of being converted to steam energy. Also, electricity generation systems utilizing plant waste, although small in scale, have been developed. Some of the systems actually are used in some industrial fields.

Because 70 percent of the wood consumed in Japan is imported, it is unthinkable to use good wood as fuel.

The majority of the wood that is used as fuel is unusable wood, such as forestry debris, wood scraps and plant waste. Important areas to pursue to fully develop these materials are collection techniques and the proper management of forests by clearing away forest debris. A series of utilization techniques covering fuel material collection, transportation, processing, storage and utilization must be developed organically, instead of having each operation exist independently, and the system must be compatible with the demands and needs of society. The "Survey for Promoting Wood-Type Energy Utilization" is carried out to study these points.

Japan has a fairly extensive amount of data on forest management techniques relevant to the use of forest wood as fuel. In this case "management" consists of replanting trees to replace the ones cut down, with most districts following this conservation practice.

There has been no reevaluation study since the 1950s, but existing data will be useful because it embodies accumulated experience and the results of studies that are going on currently.

Appraisal of Fuel Wood and Charcoal

Wood-type fuel and charcoal have been replaced by petroleum-derived fuel so rapidly for many reasons. Probably the most important reason was that petroleum-type fuel became available at a lower cost, and the modern distribution system allowed it to be distributed very easily.

However, as a result of the two oil crises, the oil supply has become very uncertain, and its price has multiplied many times. Its advantageous position is problematic. This prompts a reevaluation of wood-type fuel, an area in which Japan has a long history of actual use.

Wood-type fuel prices increased during the past 10 years to some extent, but kerosene prices have increased at a much higher rate. Ten years ago, petroleum was definitely the cheapest source. For example, the price of charcoal was about five times higher than that of petroleum and wood-type fuel and ogalite were about twice as expensive as petroleum. At present, the price of charcoal is about 2.2 times higher than that of petroleum, indicating a smaller difference in price. Wood-type fuel and ogalite is only .8 times as expensive, which means that the price differences are much smaller than before. Thus, wood-type fuel is fairly competitive with petroleum. However, the equipment which burns petroleum has been developed to a much higher level and its heat efficiency is much higher than that used for wood-type fuels. The calorific value of wood-type fuel is greatly affected by the moisture content ratio. Accordingly, there is a certain amount of variation to be allowed for when comparing the economic benefits of both. When one considers the technical achievements related to wood-type fuel as evidenced by improvements in the combustion equipment in recent years, it can be safely said that petroleum is losing its absolute superiority.

TABLE 1. PRIMARY ENERGY SUPPLY IN FY 1979

Energy type	Ratio (%)
Hydro power	5.1
Nuclear power	4.2
Coal	14.0
Domestic	2.9
Import	11.1
Petroleum	71.1
Domestic	0.1
Import	71.0
LNG	4.9
Natural gas	0.6
Fuel wood & charcoal	0.1
Total	100.0

TABLE 2. EXPENDITURES RELATED TO RESEARCH AND DEVELOPMENT BY ENERGY TYPE

(Unit: ¥100 million)

Type		Budget (Fiscal year) 1979	1980
Nuclear power		1,749	2,220
Fossil energy	Coal	54	247
	Petroleum Natural gas	46	141
Sub-total		100	388
Natural energy	Geothermal	36	95
	Solar	38	96
	Oceanic	5	3
	Wind	1	1
	Biomass	1	6
Sub-total		80	202
Energy effective use		80	150
Others		24	44
Total		2,034	3,004

(Source: Science & Technology Agency)

TABLE 3. ELECTRIC POWER SUPPLY FACILITY SITUATION

(End of March 1980)

	Output (MW)	Configu-ration ratio	Generation volume (10 KWh)	Configu-ration ratio
Hydroelectricity	28,309	20.5	85,044	14.4
Steam power	94,500	68.5	434,207	73.6
Nuclear power	15,130	11.0	70,393	11.9
Total	137,939	100.0	589,644	100.0

Soviet Union

CONTENTS

INTRODUCTION

The Soviet Union has great reserves of natural, nonrenewable energy resources accounting for about 40 percent of the world fuel reserves and a significant hydro power potential, of which a mere 16 percent has been put to work to date. This provides the conditions for basing the development of the country's fuel and energy complex on the domestic energy resources in the foreseeable future.

The structure of energy consumption that has evolved in the Soviet Union determines the short-term development of the fuel and energy complex. Under the five-year economic development plan for 1981-1985, provisions have been made to bring electricity output up to 1,550,000 million to 1,600,000 million KWh, including 220,000 million to 225,000 million KWh at the atomic power stations and 230,000 million to 235,000 million KWh at the hydroelectric power stations. The increased electricity generation in the European part of the Soviet Union will be realized by the construction of atomic power plants. The building of large hydroelectric power stations will be continued on the rivers in Siberia, the Far East and Central Asia, with due account being taken of the integrated utilization of water resources. The construction of thermal power stations will be carried on at accelerated rates on the basis of the Ekibastuz and Kansk-Achinsk coal basins and also natural and associated gases from fields in western Siberia. Work is being pursued to further develop the country's integrated power grid and district heating.

The output of oil and gas condensate is planned to be increased to 630 million to 645 million tons. The oil industry is to be developed at increased rates in the regions of western Siberia, the Kazakh SSR, and the north of the European part of the country.

The gas industry will be developed at accelerated rates: in 1985 natural gas output is to amount to 600,000 million to 640,000 million cubic meters. The construction of high-capacity gas pipelines, automated to a large extent and with high operational reliability, is to be continued. The capacities of underground storage facilities are to be increased significantly. The capacities for comprehensive processing of oil, gas and natural gas to recover ethane, sulfur and other associated components are to be stepped up, too.

Oil output will be brought up to 700 million to 800 million tons due to the accelerated development of the Kuznetsk, Kansk-Achinsk and Ekibastuz coal basins. Open-cast coal mining will go ahead at priority rates.

Up to the end of the 20th century and in the early 21st century, the Soviet fuel and energy complex will be characterized by the following trends and uniformities:

- Enhanced effectiveness in the utilization of energy resources in the national economic sectors due to the introduction of new energy-saving technologies and the increased efficiency of power generating and power consuming equipment and facilities, the large-scale utilization of secondary energy resources, the reduction of the energy intensity of production, and the evolution of a lifestyle toward the more economical consumption of energy.

- An accelerated growth of the share of electricity in the country's energy balance due to the relatively stable indicators of its value with the increase in world oil and gas prices which engenders the prerequisites for the extensive introduction of electric energy into the national economy, not only as a crucially important method for improving labor productivity but also as a way of reducing the share of oil consumption in the energy balance.

- Substantial shifts in the country's energy balance structure toward a greater proportion of effective energy carriers in energy consumption (electric energy and natural gas, primarily). The growth of the country's energy capability, then, will proceed mainly due to the use of gas, and then nuclear fuel and low-cost coals.

- A substantial increase in oil extraction costs which, coupled with growing oil prices on the world market, will result in the expediency of obtaining synthetic liquid fuel (SLF) from low-cost coals (primarily those of the Kansk-Achinsk coal basin).

- The need to displace liquid fuel, and later gas, from the sphere of the heat supply and district heating by using nuclear energy to assure the annual base-load curve for heat supply, and by using quality solid fuel for meeting seasonal variations in heat consumption.

- An increase in the share of district heating by nuclear energy in the form of pumped storage electric heating and thermal pumps, and also the replacement of liquid fuel and gas by solar and geothermal energy for dispersed heat users.

- High growth rates of atomic power, limited, in the short term, by the possibilities of the machine-building base, and expansion, in the long term, of the fields of effective utilization of atomic energy.

- Provision of the prerequisites for the extensive commercial utilization of renewable sources of energy: hydro power, solar energy, wind energy, geothermal waters, biomass and other nontraditional sources of energy and energy media.

- The further concentration of production of energy resources and electricity, and the centralization of their distribution.

- Continuing non-uniformity in the location of energy resources throughout the country which makes it necessary to resolve questions of power transmission over long distances, especially for supplying the needs of the European part of the Soviet Union.

- The increased impacts exerted by energy production upon the state of the environment, which necessitates the implementation of a large complex of diverse measures to prevent and neutralize the undesirable ecological consequences of energy development.

The bulk of the increase in energy consumption will be assured by growth in the production of natural gas and coal and the development of nuclear energy. In the 1990s a certain contribution to the energy balance can be expected from new and renewable energy sources (including solar, geothermal and wind), although their aggregate share together with hydro power will not perhaps exceed 5 to 6 percent of the total energy production in the Soviet Union toward the end of the century. On the whole, the proportion of new and renewable sources of energy, including nuclear energy, will grow from roughly 4 percent at present to 15 percent toward the end of the century. New and renewable energy sources are expected to make a much greater contribution after the year 2000.

According to some estimates, toward the end of the first quarter of the 21st century this category of energy resources (including nuclear energy) will already account for 35 to 40 percent of the aggregate production of primary energy resources in the Soviet Union.

Notwithstanding the relatively small contribution of new and renewable sources to the solution of the problem of supplying the Soviet national economy with energy up to the end of this century, intensive scientific investigations and experiments on the development of practically inexhaustible sources of energy are being conducted in the country. Much prominence is accorded to the development of technologies for their effective utilization. Hence, the interest that the Soviet Union is showing in exchanges of experience and international cooperation in development and commercialization of new and renewable sources of energy is quite understandable.

In the final count, the large-scale utilization of these energy sources will be determined by their economic effectiveness compared with traditional resources of fossil fuel and nuclear energy. However, the steadily rising prices of fossil fuels (especially of oil and natural gas, the most effective of them all), the uncertainties surrounding the commercial use of thermonuclear energy, and the fact that a number of questions pertaining to nuclear power development are as yet unresolved make it urgent and vital to develop more effective methods of utilizing new and renewable energy sources.

OIL RECOVERY

Increasing oil recovery is an important way of augmenting the resource base of the Soviet petroleum industry; in the future it may become a significant source of maintaining production. In the development of new oil fields, the use of these methods will, from the very first, make it possible to increase the total volume of production and its maximum level appreciably.

High world oil prices create economic conditions propitious to developing resources of "ordinary" oil fields which are not extracted by conventional oil production methods.

In the Soviet Union, preparations are underway to use several methods commercially for improving oil recovery. In 1980, pilot plant work for mastering tertiary methods of oil recovery was carried on at more than 45 oil fields.[1] The first positive results have been achieved in the application of these new methods.

Efforts are underway to develop deposits of heavy high-viscosity crude oil with fairly large proven reserves. The bulk of these reserves occurs at relatively great depths and is situated in regions with inclement climatic conditions.

The thermoshaft method for extracting heavy crude oil involving a combination of shaft sinking and exposure of the oil pool to the action of steam and heat under conditions of underground workings was developed in the Soviet Union and introduced on a commercial scale for the first time in world practice in the Yareg oil field (Komi ASSR). It is important to stress that the high oil recovery in the Yareg oil field is achieved under the conditions of very high oil viscosity -- 11,000 to 15,000 centipoise.[2]

OIL SHALE

At present, favorable conditions are taking shape for the commercial production and processing of nontraditional sources of hydrocarbons, including combustible shales. This is due first of all to the significant rises in world oil prices. In this connection, the conversion of the richest (in kerogen content) resources of oil shale into artificial liquid fuel becomes economically justified and expedient.

Because the shale-bearing capacity of the territory of the Soviet Union has been insufficiently studied, it is only possible to give a tentative evaluation of the oil shale reserves as about 2,000,000 million tons, from which it is possible to produce about 200,000 million tons of shale resin. The largest oil shale deposits are in the Baltic shale basin, the Volga shale basin, the Timano-Pechora basin and the reserves of the Domanikovy shales located in the area of the Southern Timan and along the western slope of the Urals. The yield of resin from shales from these deposits is sufficiently high and amounts to 10 to 20 percent (in weight).

Thanks to the peculiarities of their organic matter (the H:C ratio close to high-viscosity oils) and the significant content of the mineral part, oil shales represent a valuable organo-mineral feedstock suitable not only for electricity production, but also for obtaining synthetic liquid fuel, shale gas and a number of valuable chemical products and different building materials.

In this connection, the more important avenues of commercial utilization of oil shales being pursued in the Soviet Union are energy generating, technological and energy-technological.

Energy generating shale utilization involves the combustion of oil shale in the furnaces of power plants. Currently, more than 70 percent of all the shale mined in the Soviet Union is used to generate electricity. The world's most powerful thermal power plants burning oil shale (the Baltic and the Estonian State Regional Thermal Power Plants with a combined design capacity of 3,224 MW) have been built. The thermal power stations burning the shales of the Baltic basin operate in a stable and efficient way. These plants consume a total of more than 20 million tons of oil shale per annum. The experience gained by the Soviet Union in the field of using oil shales for energy generation is unique and can be of much interest to countries with reserves of low-cost shales poor in kerogen content. The Soviet Union already is rendering assistance to a number of countries in this field.

About 25 percent of all the oil shale mined in the Soviet Union is subjected to technological processing in special facilities (shaft generators) where the thermal decomposition of the shale takes place under relatively "mild" conditions (at temperatures ranging from 480°C to 700°C), which results in the liberation of liquid and gaseous products (resin, low-calorific gas and pyrogeneous water).

Resin produced in the thermal decomposition of shale is a valuable feedstock for obtaining different synthetic liquid fuels -- motor petrol, motor kerosene, diesel fuel and furnace fuel oil.

At present, shaft generators alone are used in the Soviet Union to produce shale resin. The capacity of shaft generators is 240 to 250 tons of oil shale per day, and the resin yield is about 170 kilograms per ton of shale. The construction of shaft generators with a capacity of 1,000 tons per day is underway.

However, it should be noted that gas generators are only effective in processing lumpy shale. Because of the tendency for the mechanized production of shale to grow continuously, the problem arises of refining shale down to fines (lump size smaller than 25 millimeters), which develops when this mechanized method of mining is used. In this connection, of considerable interest is the energy-technological processing of shales involving heat treatment of shale having lump sizes of up to 25 millimeters with a solid ash heat carrier at a temperature of 480°. This results in the production of high-calorific and low-sulfur power-generating fuels and feedstocks for the chemical and building industries, and agriculture.

The method has been tested and optimized in two pilot installations with shale outputs of 200 tons per day and 500 tons per day. The latter installation has processed 2 million tons of shale and produced 270,000 tons of shale oil and 100 million cubic meters at NTP of high-calorific gas.

In 1980, the first of the two commercial installations for energy-technological processing of shale with a shale output of 1 million tons per year (3,330 tons per day) was put into operation at the Estonian Regional Power Plant. It is to produce a total of 130,000 tons of shale oil, 54,000 tons of high-calorific gas (including 7,500 tons of gas-derived gasoline) annually from shale mined in the Baltic basin. The commissioning of another such installation is expected in 1981-1982. The combined efficiency of the process (calculated with respect to the low heat value) amounts to 86.3 percent with due account being taken of production losses. However, the yield of resin, with the energy-technological processing of Estonian shale, under the conditions of low-temperature carbonization is not high and makes up about 55 percent of its organic part.

In recent years, the development of other effective processes for the technological conversion of shales has been in progress in the Soviet Union. One such process is the method of thermal dissolution of shale.[3]

The process is carried out, at a pressure of 30 to 50 atmospheres and at temperatures ranging from 410°C to 430°C, with the use of a special solvent (a liquid fraction with a boiling temperature range between 210°C and 340°C) obtained in the process of the thermal dissolution of shale. In these conditions, without the use of a catalyst, the destruction of the organic part of shales takes place. Its transition into a soluble state and cracking is accompanied by the liberation of gas and a liquid fraction which separates into a gasoline fraction with a boiling temperature range of 180°C to 200°C, a regenerated solvent and an extract with a temperature range higher than 320°C to 370°C.

At present, the simplest variant of this process has been tried out, producing a high-boiling extract (which can find application as an ash-free power-generating fuel and also as a feedstock for obtaining electrode pitch coke, bitumens and an organic binding material for highway construction) and a liquid fraction. With the further processing of the liquid fraction, evaporated by boiling up to a temperature of 350°C, it is possible to obtain a high-octane motor fuel by the methods of hydrogenation and catalytic reforming. Depending on the process temperature, the yield of products, relative to the shale organic part (with the solvent's full regeneration and discounting losses), is as follows: gas, 3 to 11 percent; crude petrol fraction with boiling temperatures of up to 200°C, 8 to 30 percent; and ash-free extract, 40 to 70 percent.

Major advances have been made in the Soviet Union in converting solid fuels by the method of high-speed pyrolysis which permits the following pyrolytic products to be obtained (owing to superquick heating for 10^{-4} to 10^{-1} seconds, to the temperatures of 500°C to 900°C): coke breeze, gas, pyrogenic moisture and resin. Upon further processing these furnish a valuable feedstock for the production of high-octane motor fuel and a number of chemical products (such as phenols and aromatic hydrocarbons).

The energy-technological method of high-speed pyrolysis of coals developed at the Krzhizhanovsky Energy Institute has best been developed for commercial utilization. At a later stage, this technology also will be employed for shale conversion. Several pilot installations with capacities of 30,000 to 90,000 tons of coal per annum, which have converted tens of thousands of tons of coal, are already in operation in the Soviet Union. The new method of pyrolysis is distinguished from the conventional low-temperature carbonization by the simplicity of the process schemes, high intensity, high unit capacity (175 and 500 tons per hour), high energy efficiency (up to 85 percent) and a large yield of resin and gas.

Currently, a lead full-scale facility is being built according to an "energy technological scheme." The facility will have an output of 1.2 million tons of coal per annum, or .65 million tons reference fuel[4] (trf) per annum. It will turn out .62 million trf of other products, including: .22 million trf of resinified coke breeze, .12 million trf of coal briquettes, .15 million trf of resin and .13 million trf of pyrolytic gas.

The energy-technological conversion of solid fuels is a highly effective process. Its principal elements have by now been sufficiently well optimized and tested in industrial conditions. In the long term, this method is to become the main trend in utilizing oil shales in the Soviet Union. It is likely that the commercial-scale production of synthetic liquid fuel will begin in the country with the processing of the shales sufficiently rich in kerogen (the reserves of which are significant in the Soviet Union) and also on the basis of high-speed pyrolysis and hydrogenation of coals.

PEAT

Much experience has been accumulated in the Soviet Union in utilizing peat for energy production. The country has large reserves of peat. Potential reserves amount to 157,200 million tons, including proved reserves of about 48,000 million tons. More than 70 percent of the potential reserves are situated in the Urals and western Siberia.

In 1980, peat output totaled 84 million tons. Of this amount, 35 million tons was allocated to meet agricultural needs, such as fertilizer and litter for cattle. Twenty-seven million tons of peat (9.18 million trf) was used for energy production. The production of peat briquettes as a quality fuel for communal and household uses is proceeding; 9.2 million tons of peat was used for these purposes, yielding 5.3 million tons of briquettes (3.18 million trf).

The Soviet Union is one of the few countries where the combustion of peat for heat and electric energy generation is organized on a fairly large scale. In 1980, peat consumption by thermoelectric plants and district heating plants amounted to 5.6 million trf. Thermoelectric plants consumed 4.1 million trf; district heating plants consumed 1.5 million trf.

At present, power-generating units with outputs of 200 MW operate at the Shatura, Cherepovets and Smolensk electric power plants. The installed capacity of these plants is 600 MW.

In the long term, a significant expansion of peat utilization in energy production is not envisaged. However, because the Soviet Union has unique experience in peat development and utilization, it can render aid to other countries (mainly developing ones) which have significant peat reserves and a surplus of labor.

HYDRO POWER

Hydro power plays a prominent part in Soviet electricity generation, both in the installed capacity of the hydroelectric power stations and in the volumes of electricity generated. The aggregate installed capacity of hydro power stations as of early 1980 stood at 49.9 million KW (20.8 percent of the installed capacity of all the country's electric power stations). In 1980, the hydroelectric stations generated a total of 183,000 million KWh, of which 80,400 million KWh fell to the share of the European part and 102,600 million KWh to that of the Asian part of the Soviet Union.

In the scale and technical level of hydraulic power engineering and the construction of hydro power facilities, the Soviet Union ranks with the world's most advanced countries.

The utilization of the water power of the Soviet Union's main rivers is being pursued with emphasis on building cascades of hydroelectric power stations for the fuller and more effective utilization of water resources. The consistent "river system" construction of electric power stations facilitates the organization of construction and installation work, and in a number of cases it is only a cascade of integrated hydro-schemes that accomplishes the tasks involved in the integrated utilization of rivers for hydro power generation, irrigation, water supply and water-borne traffic.

The largest integrated cascades of water power projects built in the European part of the Soviet Union are the Volga, Kama and Dnieper river systems.

The high-capacity hydroelectric stations of Siberia are highly effective sources of energy, especially the Angara-Yenisei cascade, which consists of four high-capacity hydroelectric power stations -- the Bratsk, Ust-Ilim, Krasnoyarsk, and Sayano-Shush stations -- with a combined output of 88,000 million KWh under annual mean flow conditions.

A number of hydroelectric power stations in Central Asia, besides generating electricity, are crucial to utilizing annual river runoff for irrigation.

Long-term hydro power development will be marked by a qualitative change in the structure of the country's fuel and energy balance; the gradual development of the hydro power potential in the industrially advanced European regions; the need to regulate the runoff toward the integrated utilization of water resources and a simultaneous tightening up of the regulations pertaining to environmental protection. The guidelines for long-term hydro power development in the country's different regions are as follows:

- In the European part of the country: The maximum utilization of hydro power resources with the objective of moderating stresses in the fuel and energy balance in this region, and the construction of special mobile hydroelectric pumped storage power plants for enhancing the efficiency and reliability of the operation of energy-generating systems.

- In Siberia: The construction of large hydroelectric power stations on the Angara, the Yenisei and the upper reaches of the Ob, regarded as a crucially important element of the largest fuel-and-energy base being created in the country's east.

The utilization of the abundant hydro power resources of Siberia is linked with the development of a production, social and institutional infrastructure, the establishment of territorial and production complexes and the accelerated pioneering of new regions.

- In the Soviet Far East: The construction of hydroelectric power stations on the Vitim, the Olekma, the Bureya and the Kolyma, to create an energy-generating base for economic development in the area of the Baikal-Amur railway and in remote regions of the northeast.

- In Central Asia and Kazakhstan: The construction of multi-purpose hydro power schemes ensuring river runoff control and for electricity generation and the development of irrigated farming.

The overall level of the possible utilization of hydro power resources in the Soviet Union in the foreseeable future may attain 450,000 million to 500,000 million KWh, with the economic potential amounting to 1,095,000 million KWh.

Thus, in the foreseeable future the proportion of utilization of the economic hydroelectric power resource potential will reach 40 to 45 percent of the total.

Soviet hydraulic engineering science and designing practice have reached a level which has made it possible to get down to the construction of unique hydroelectric power stations and water-development projects under the most complicated natural conditions.

Hydraulic power engineering in the Soviet Union traditionally occupies a leading place in the world in the construction of major hydroelectric power stations upon non-bedrock foundations. All the hydroelectric power stations on the Volga and the Kama have been raised on such foundations.

Some dams erected in the Soviet Union rank among the world's highest: the Nurek earthen rock-fill dam standing, 300 meters high; the Inguri arch dam, standing 271 meters high; the Sayan-Shush archgravity dam, standing 242 meters high; and the Chirkey arch dam, standing 295 meters high.

It should be stressed that most of these unique structures have been built or are being built under complicated engineering and geological conditions in high-seismicity areas.

The massive gravity dams used at the Bratsk, Krasnoyarsk and Ust-Ilim hydro schemes have proved to be the simplest to build and the most effective economically under the conditions of the copious Siberian rivers.

In the past few years, the building of pumped-storage hydroelectric power stations has been started in the Soviet Union. These stations are to maneuver capacity in the Inter-connected Power System of the European part of the country.

The power plant industry of the Soviet Union develops and manufactures hydraulic turbines of different systems: propeller and axial-flow (Kaplan) turbines; adjustable blade (Darrieus) turbines, radial-axial (mixed flow) turbines, Pelton turbines of different capacities, and horizontal enclosed units.

The largest in size, the propeller turbines (Kaplan) with turbine-wheel diameters of 10.3 meters and 10 meters, operate at a number of hydroelectric power stations in the Volga-Kama cascade.

Adjustable-blade turbines are highly effective for hydroelectric power stations with heads of up to 125 meters and with wide-ranging head fluctuations. In 1976, adjustable-blade 220 MW turbines, with a wheel diameter of 6 meters, designed to operate over the head range of 40 through 97 meters were put into operation at the Zeya hydroelectric power station. The question of using adjustable-blade turbines for a head of up to 150 meters is under consideration.

Radial-axial (mixed-flow) turbines, suitable for the 40 to 600 meter head range, have become quite common. The largest of them are the hydroturbines installed at Sayan-Shush Hydroelectric power station (640 MW; radial head, 194 meters, wheel diameter, 6.5 meters).

Impulse (Pelton) turbines are used for heads exceeding 400 meters.

Turbine pumps, each with a capacity of 200 MW and a wheel diameter of 6.3 meters, have been developed for the high-priority Zagorsk and Kaishyador pumped storage hydroelectric power stations.

Much experience has been gained in the Soviet Union in the construction of small-scale hydro projects, ranging in capacity from several dozen kilowatts to several megawatts. A large number of such hydroelectric power stations were built in the 1930s through the 1950s across the country. In the past 20 years, the construction and operation of most small-scale hydroelectric power stations have been discontinued because of their low efficiency, and in connection with the development of the power grid whch has encompassed virtually the entire country. The harnessing of small streams and the utilization of head differentials in unitized automated hydroelectric generating sets which do not require attendant personnel can provide an additional several thousand million kilowatt/hours of electricity per annum, and thus replace up to 1 million tons of fuel.

The step-by-step development of hydro power resources in the Soviet Union, and especially in the country's eastern regions, is part of the general trend toward the development of renewable energy resources in the long term.

TIDAL POWER

The Soviet Union has significant tidal energy resources (a total of 350,000 million KWh per annum), which accounts for about half the world's technical potential.

Because the sites for the possible construction of tidal power plants are located in uninhabited areas along the White Sea and the Sea of Okhotsk, coasts with inclement climates, a floating construction for the building of the Kislaya Guba (bay) tidal power station was developed and realized for the first time in the practice of building hydroelectric power stations. This construction has been adopted for all the tidal power schemes designed in the Soviet Union and abroad, in Canada, Great Britain and South Korea.

SOLAR ENERGY

Possibilities for the large-scale utilization of solar energy are relatively limited in the Soviet Union. This is due to a number of objective natural and socioeconomic factors. Solar energy can be used mostly to supply heat to scattered users in the country's southern regions and electricity to small, remote facilities which could secure, toward the close of the century, an economy of fossil fuels in the amount of several tens of millions of tons of trf per annum.

Low-Grade Heat and Refrigeration Supply

This trend in solar energy utilization is the most promising for the Soviet Union. The southern regions (south of latitude 50° north) lying in clear-sky zones are characterized by the insolation of 1 square meter of a solar collector, optimally oriented in space, in an amount ranging from 1.5 to 2 Gcal per square meter per annum. Thus, assuming the average efficiency of solar radiation conversion into low-grade heat to be equal to 40 to 50 percent (flat plate solar collectors heating the heat-transfer medium to a temperature exceeding the ambient temperature by 50°C to 60°C), 1 square meter of the solar collector will make it possible to obtain .6 to 1 Gcal per square meter per annum, which is equivalent to a saving of .1 to .3 trf per square meter per annum.

These figures are approximate, for they are obtained without account being taken of variations in the seasonal graphs showing heat demand and the amount of incoming solar radiation. Seasonal variations mainly make themselves felt in the optimal proportion of annual heat consumption, made good by solar radiation.

With the standard investment efficiency rate being 12 percent and depreciation costs 5 percent, and given the 20-year long service life, irrespective of the current costs of running a solar plant, the minimal marginal fuel costs at which the introduction of solar installations is economically expedient are as follows: with an installation costing 150 roubles per square meter, 130 roubles per trf; with an installation costing 100 roubles per square meter, 85 roubles per trf.

If we take the price of oil on the world market, which now stands at about $40 per barrel (about $250 per trf) to be the determining factor, then the operation of solar systems for the production of low-grade heat is justified in a number of cases even now, especially if they displace liquid and gaseous fuels.

To date, about 30 pilot facilities with systems for solar heat supply have been built in the Soviet Union.

A number of scientific institutions conduct research for the purpose of developing economical heating and air conditioning systems powered by solar radiation. Air conditioners powered by solar energy, to be used in arid and hot climates, have been developed.

There are certain possibilities for utilizing solar energy in agriculture. The seasonal nature of agricultural production and a large number of small and scattered users predetermine the favorable possibilities.

In Kazakhstan and Central Asia there are numerous desert and semi-desert pastures, occupying an area of more than 200 million hectares, which have sufficient reserves of fodder but lack fresh water from livestock because of the high mineralization of the groundwater (up to 35 grams per liter). The use of these pastures would allow the sheep population to be increased substantially. The operation of solar prototype desalinization plants developed and tested under the conditions of the Turkmen SSR, the Uzbek SSR and the Kazakh SSR has shown their fresh water output to be 1 ton per square meter per annum, capital construction costs to be 45 to 50 roubles per square meter and the cost of fresh water to be 2.5 to 3 roubles per cubic meter, which is in many cases cheaper than delivering it in tankers.

A new idea of organizing the supply of water to remote pastures through the construction of heliocomplexes in the desert has been put forward in the Soviet Union. Such a heliocomplex will comprise a solar-powered desalinization plant with a water elevator, a house for shepherds with heat and electricity provided by the sun,[5] a helio-hothouse for vegetable growing and a vat for growing chlorella as a feed additive. Currently, such complexes are being tested for feasibility.

Helio-hothouses are extremely promising. Depending on the purpose and climatic conditions, a fuel savings up to 70 percent can be obtained and in a number of cases the back-up fuel economy[6] can be dispensed with as demonstrated in the operation of pilot helio-hothouses in Uzbekistan and Turkmenia where at night temperatures drop to -20°C.

It is difficult to forecast the scale on which solar plants will be introduced for generating low-grade heat and for agricultural uses up to 1990. However, it appears quite feasible that by then the use of solar energy will have allowed the saving of up to 1 million trf of fossil fuels per annum. This will require the installation of up to 5 million to 7 million square meters of collectors, provided they are operated the whole year; considering the seasonal nature of heat consumption, 7 million to 10 million square meters of collectors will be necessary. More than 100 million square meters of solar collectors will be required to save about 20 million to 30 million trf of fossil fuels by the year 2000.

The Thermodynamic Method of Converting Solar Energy

In the Soviet program for solar energy utilization, much emphasis has been laid on establishing relatively large solar electric power plants which will operate on the basis of machine thermodynamic cycles and produce electric and thermal energy on a commercial scale.

The economic efficiency of such stations integrated into power systems is determined by the recoupment of the capital outlays for their construction, resulting from the savings of fuel and costs of environmental protection measures.

According to design evaluations, the unit cost of a large steam-turbine solar power plant (in 1979 prices) may fluctuate between 750 and 900 roubles per kilowatt, with marginal costs of 8 to 10 kopecks per kilowatt hour, which exceeds several times the electricity production costs at thermal power stations on fossil or nuclear fuel.

Research and development in this field will be aimed at technological and technical-economic quests to enhance the efficiency and competitiveness of solar power plants.

In the long term, the schemes of solar power plants of a tower type could utilize photocells capable of operating at increased temperatures (over 300°C) and at high radiation densities. One may assume that the use of photocells on the surface of solar power plant collectors will make it possible to increase the overall efficiency of converting solar energy to electricity as much as 35 percent or more. This may become economically justified if relatively low-cost photovoltaic converters are developed.

In accordance with the program for the further study of the possibilities for using solar power plants in the Soviet energy sector, provisions have been made to build and test the country's first experimental solar power plant in the Crimea, with an output of 3 to 5 MW, which will comprise all the basic elements of a commercial solar power plant of the tower type.

Photovoltaic Conversion of Solar Energy

Of all the known methods of direct conversion of solar energy into electricity, the photovoltaic method of energy conversion with the aid of semiconductor photovoltaic solar power systems (PSS) is the best tested one under the conditions of longtime operation on earth and in outer space.

The merits of photovoltaic systems are linked with the possibility of using them virtually in any geographical region, their high reliability, long service life (more than 30 years), independence of operation and ecological purity of the energy source.

The main drawback of photovoltaic systems is their high cost, which is the chief factor hindering their wide application in the future.

The cost reduction program includes the following measures: (1) the utilization of low-cost silicon in the form of a tape or film obtained with the help of low-cost, high-speed processes (casting, zone melting, extrusion or rolling of polycrystal silicon); (2) the development of a continuous automated production process all the way from the production of pure material to the assembly of solar cell batteries; (3) the employment of simplified methods of printed contact making; and the application of low-reflection coatings by atomization and vacuum deposition.

In the Soviet Union, the solution of problems involved in the reduction of photovoltaic converter costs is based, apart from the above ways, on the program (advanced in the early 1970s) of utilizing the concentration of solar radiation, involving the saving of high-cost semi-conductor materials and the use of relatively low-cost concentrators.

Long-term programs are being drawn up for the development of ground-based solar power facilities, and groups of leading scientists and research staffs are engaged in relevant research. The main aim of the program is to drastically reduce the costs and the power consumption involved in the production of semiconductor materials and solar cells, and to develop modules and power units for high capacity photovoltaic systems and heliocomplexes for their testing. In the event of a technological breakthrough in this field capable of reducing solar cell costs by approximately a factor of 10^2, one can expect radical changes in the structure of the energy supply.

Currently, in ground-based applications of photovoltaic converters emphasis is on silicon solar cells. Economic calculations show that even at a cost of 50 roubles per watt, the use of photovoltaic converters is expedient for supplying energy to small, remote users operating units of up to 500 watts. About 120 solar electricity-generating facilities using photovoltaic modules in gas-filled glass protective shells are in operation. They are installed on lighthouses, navigation marks, gas pipeline cathode protection setups in the Azerbaijan SSR and in Central Asia and similar locations. Their aggregate capacity is 10 KW. Efficiency ranges between 8 and 10 percent, and the service life is more than 30 years.

The large-scale utilization of solar energy is in the initial stages in the Soviet Union. By now, some experience has been accumulated in the development and experimental utilization of solar energy. For the immediate years ahead, provisions have been made to launch the pilot plant operation of facilities, using solar energy in the country's more promising regions. The results of these tests will furnish grounds for an ultimate evaluation of the expediency and scope of solar energy development.

GEOTHERMAL ENERGY

According to data released by the Academy of Sciences and the Ministry of Geology, the prospected reserves of thermal waters at depths of 3,000 to 3,500 meters with temperatures ranging from 40°C to 200°C and a mineralization of up to 35 grams per liter can assure a longtime recovery at a rate of 20 million to 22 million cubic meters per day. Most of these waters find their way to the surface by spouting. More than 70 percent of the prospected subsurface hot water storage falls to the little-developed regions of Siberia and the Far East. Almost 90 percent of all the thermal waters have temperatures below 100°C.

These two circumstances do not hold promise, even in the long term, of supplying a significant proportion of the country's demand for low-temperature heat and electricity by thermal waters, although it is beyond question that in better endowed regions geothermal energy will be used primarily to provide local household and agricultural users with heat.

Great thermal energy reserves are trapped in permeable water-bearing strata and in "dry" rock masses lying at significant depths. The schemes for the effective utilization of this heat on a commercial scale are in the stages of scientific and technical evaluation and experimental testing. To obtain petrogenic heat, it would be necessary to involve great volumes of rock masses with a multitude of natural and man-made fractures uniformly encompassing the entire volume between the boreholes for pumping down cold water and recovering hot water or steam; otherwise, the rock mass would become cool quickly in the zone of the most active circulation, and this zone would deliver slightly heated water although the bulk of the mass still would be hot. In the case of water-saturated strata, the same difficulties may arise because of the uneven permeability of the entire volume of a stratum. The question of exploiting man-made circulation systems is extremely complicated due to the fact that the chemistry of the interaction between the waters containing oxygen and carbon dioxide and the rocks has been insufficiently studied. For this reason, heat from water-saturated strata and hot dry rock systems, immense though it is, has not yet been included in the recoverable geothermal reserves.

For the most part, thermal water resources are noted for the exceedingly high content of salts dissolved in them as well as other chemical compounds which virtually exclude the possibility of discharging spent waters into natural water bodies. The most rational scheme regarding environmental protection is to pump spent water down the stratum again. However, this increases costs of utilizing geothermal heat and can become an impediment even in the most richly endowed regions.

Low-grade geothermal resources (thermal waters with temperatures of up to 100°C) are used in our country for heating frozen rocks and dredging grounds in the development of placer deposits of minerals in the northeast, for supplying water to livestock complexes, for hot water irrigation, for sporting and health purposes (such as swimming pools and showers), for the intensification of fish breeding, for the provision of heat and hot water to residential and industrial buildings, and for the heating of hothouse and hotbed complexes.

The main constraint limiting the use of thermal waters with temperatures below 100°C is the lack of suitable users on the spot and, what is more important, the ecological limitations on the discharge of spent waters (either highly mineralized or containing harmful impurities) into surface water bodies.

The second category of geothermal resources comprises thermal waters and hot springs with temperatures ranging from 100°C through 200°C. This heat can be used effectively in many sectors of the national economy. Overheated thermal waters can and do find application in electricity generation by small-capacity installations using low-boiling working fluids (such as isobutane and freon). At a later stage, they could be used as thermal low-grade waters, for processing and power-and-heat supply purposes. Finally, hot springs with temperatures ranging from 150°C to 200°C can be used to generate electricity.

Geothermal Heat Supply

Inasmuch as the bulk of the thermal water reserves in the Soviet Union are in the low-temperature category, their main uses in the foreseeable future will be for agriculture and communal heating and water supply.

Natural heat utilization holds the greatest promise and economic advantage for agriculture. Greenhouses have been set up across the country, from the subtropics to the arctic regions.

The problem of developing vegetable growing in hothouses in many regions of the country, provided traditional fuels for their heating are replaced to a maximum extent, can be resolved successfully by switching hothouse complexes to geothermal heating either fully or in part. The economic effectiveness of thermal water utilization is well illustrated by the example of the hothouse combine of a state farm located not far from the city of Grozny. The outlays for the construction of one film-covered hothouse there, covering an area of 500 square meters, were recouped within a year.

Much attention is being given to the provision of fresh vegetables to regions where climatic conditions do not permit their cultivation. Many such regions lack local fuel, and its delivery over long distances is fairly costly; therefore, geothermal energy in such regions is regarded as virtually the only way of developing vegetable cultivation.

Large geothermal agricultural complexes are being set up in many regions of the country. For instance, one such complex is effectively functioning in the Northern Caucasus, in the Mostovsky region of the Krasnodar Territory. The hothouse complex, covering an area of 10 hectares, is heated with thermal water with an initial temperature of 74°C. The spent water with a temperature of 35°C to 40°C is channelled to a livestock farm and a pond, with an area of 200 hectares, where mirror carp are bred.

Geothermal hothouse-and-hotbed complexes are being widely introduced in Northern Caucasus region and Transcaucasia. For example, in the Georgian SSR the Kindgsky hothouse combine, with an area of 54 hectares, is being established on the basis of the local hot water springs.

Geothermal Heating and Hot Water Supply

Schemes for geothermal heating and hot water supply have been developed for a number of the regions in the country.

Let us dwell briefly on just one such scheme for the comprehensive utilization of thermal waters within an urban heat supply system. The same thermal water well can serve different numbers of users, depending on the temperature of water coming to the surface and the climatic factors. For instance, one thermal water well, with a flow rate of 1,500 cubic meters per day and an outflow temperature of 50°C, supplies heat to seven houses, each having 70 flats, in the city of Makhachkala. It allows a savings of a total of 1,200 trf if there is a parallel delivery of thermal water for heating and hot water supply. However, with a combination of additional water heating for peak power load, and warm-air and hot-water heating, the fuel economy increases to 3,100 trf and the number of 70-flat houses served by the well increases to 16 or 17.

The heating of thermal water for peak loads can be done in conventional boiler rooms (houses) equipped with steam generators and hot-water boilers and by means of electricity. In the latter case the peak-load boiler room (house) is fully automated and operates without any attendant personnel. Fuel consumption is very low because the peak-load boiler room has to function only during an insignificant part of the heating season.

At present, small separate districts of the cities of Tbilisi and Makhachkala, and also a number of small towns and settlements, are provided with geothermal heating and hot water piped to residential and industrial buildings.

In the next few years, major cities such as Alma-Ata, Tashkent, Tyumen, Omsk and Petropavlovsk-Kamchatsky are to be switched over to a geothermal heat supply.

The development of thermal waters is proceeding not only along the line of a heat supply, but also to produce low temperatures with the aid of refrigerating machines.

A bromine-lithium absorption refrigerating machine, producing cold at the rate of 2.5 million kcal per hour, has been tested and is being used commercially in the Soviet Union. It not only operates on electricity, but also uses subterranean hot waters and waste water from industrial enterprises and thermal power stations. This facility is remarkable in that it not only produces cold but is also a heat transformer. It can operate all year, producing cold in summer and heat in winter.

Low-grade geothermal resources are a large energy reserve in the mining industries; they are used to heat frozen rocks in the gold, diamond and tin fields of the northeast, melt ice, and heat the metalwork of dredges over dredging grounds and marine alluvial deposits of the continental shelf.

More than 70 chemical elements are found in thermal waters, in a dissolved state. They are often in high concentrations, which makes such waters an important feedstock for the chemical industry as well.

The accompanying recovery of chemical components in heat utilization not only affords additional economic gains (just as associated heat utilization in the recovery of chemical components from water), but it also is an imperative necessity for protecting the natural environment against pollution.

In many artesian basins and in mountainous-folded regions of the Soviet Union there are large reservoirs of thermal waters effectively used at health resorts and in swimming pools.

Geothermal Electric Power Generation

The possibilities of using geothermal resources for electricity generation are limited in the Soviet Union. The most promising regions for this are those of modern volcanism: Kamchatka and the Kuril Islands.

In Kamchatka, hot springs with temperatures of 200°C to 250°C have been discovered at depths ranging from 500 to 1,500 meters. The forecast reservoirs of thermal waters and hot springs in Kamchatka are capable of meeting the region's demand for electricity and thermal energy fully.

The experience gained in operating the Pauzhetskaya geothermal power station has shown its reliability and economic efficiency. The cost of electricity is 3 to 5 times less than that at diesel electric power plants of equal capacity, which are the most common type in different regions of Kamchatka.

Thermal anomalies of up to 170°C to 200°C have been discovered at depths of 4 to 5 kilometers in regions of mountainous-folded formations (the Caucasus, the Crimea, the Carpathians and the Pamirs). Small-scale pilot plant geothermal power stations with capacities of up to 10 MW are to be built on the basis of these anomalies.

On the whole, geothermal energy will be utilized for a low-temperature heat supply, and only in the zones of recent volcanism will geothermal energy be used to generate electricity.

At the same time, a large amount of research and exploration work is to be undertaken to utilize the heat of water-saturated strata and dry rock systems which, given favorable results, can become a source of virtually inexhaustible energy.

WIND ENERGY

The development of research and practical work in the field of wind power for energy generation in the Soviet Union was started in the very first years of Soviet government. In the 1920s, E. E. Zhukovsky and his pupils developed the theory of ideal and real windmill systems, investigated loads developing on a wind wheel, and tested various designs for high-speed windmills. The Central Wind Power Institute was founded in 1930. The world's largest (at the time) wind-operated power station, with a capacity of 100 KW, was built and put into operation in the Crimea in 1931. It successfully operated up to 1942, delivering energy to the local power grid.

Recently, interest in wind power utilization has revived in the Soviet Union. The building of wind-operated units is considered promising for supplying energy to dispersed user installations in regions where there are no sources of centralized energy supply. As a rule, units of low and medium capacities (up to 100 to 200 KW) will be used.

Regions with large wind power resources are the Arctic zone, the southern Black Sea-Sea of Azov zone, the Aral Sea-Caspian zone, the Baltic Sea coast and the Pacific coast. These zones are noted for the highest wind velocities and frequent recurrence intervals. Within the lowest surface layer, annual wind velocities average 5 to 10 meters per second, wind flow duration ranges from 270 to 320 days per annum with a wind velocity averaging 8 meters per second and more, and winds blow from 30 to 60 percent of the time.

However, in selecting zones for rational wind energy utilization it is necessary to take into account such specific conditions as non-uniformity of the energy over time, the nature of energy consumption and the influence of landscape factors.

The best prospects for operating wind-powered units are in agriculture and land amelioration. The need for wind power plants is especially acute in providing watering places for livestock breeding on remote pastures in the country's southern arid and semi-desert regions, far removed from power systems. The maximum design load of such a plant, depending on the depth of the water source in the form of a shaft well or an artesian well, varies from 1 to 4 KW. The water-lifting stations allow requisite water storage in reservoirs for periods of calm, which permits the use of wind-powered units without backing them up with other sources of energy.

The results of the calculation of costs (for various methods of water supply under the conditions of Kazakhstan) for lifting 1 cubic meter of water have shown that wind systems allow the annual cost of watering one sheep to be reduced by almost 66.7 percent. Simultaneously, the systems result in a significant saving in fuel, preserve the purity of water supply sources and exclude the possibility of fuel seepage into water-supply sources.

Definite prospects open up in oasis irrigation, where there is a need for wind-driven power plants with electricity outputs of tens and hundreds of kilowatts.

Water desalinating plants are suitably integrated with wind-powered plants. The continuity of a desalinated water supply is in this case assured by its storage in a standby reservoir. A 4 KW wind-operated plant in assembly with an electrodialysis desalting installation can provide small population centers with a daily consumption of 4 cubic meters of drinking water, with an average wind velocity of 5 meters per second and with a 6 grams per liter salt content of starting water.

The use of wind systems for supplying energy to meet the household needs of shepherds, reindeer breeders, hunters, geologists and people in similar occupations is acquiring growing cultural and social significance.

In a number of cases, the continuous supply of electricity necessitates the equipment of wind-powered plants with energy storage devices and sources of back-up power supply.

The main factor hindering the development of wind power generation is the relatively high cost of aerogenerators.

The most promising trend in the work of raising the efficiency of wind energy generation is increasing the speed of wind wheels, raising their aerodynamic efficiency, improving and simplifying their fabrication and using novel materials.

The pilot plant production of wind energy-generating machines has been organized in the Soviet Union.

The ABEU-6 (Russian designation) is a high-speed double blade horizontal-axial wind electro-unit. It has a wind wheel diameter of 6 meters and a power rating of the synchronous generator of 4 KW, at an estimated wind velocity of 9 meters per second, a maximum working wind speed of 50 meters per second (designed to utilize windrose winds), with the tower height up to the axis of rotation of 7 meters. The ABEU units are in trial operation in the country's different climatic zones, serving various users.

Even now, wind electro-generators of medium and small capacities can be employed and yield a substantial economic gain, especially in remote areas. But, the large-scale utilization of wind power stations appears problematic because electricity demand on the Arctic coast is limited, and the power networks of other regions with a high recurrence of strong winds are integrated into the country's power grid where the bulk of electricity generation will, in the long-term, come from atomic power plants. This being so, wind power stations, which only allow the fuel component of electricity generating costs to be saved, prove practically ineffective.

Thus, for economic reasons the use of wind-driven electric plants will be confined mainly to coastal regions, the desert regions of Central Asia and little developed regions of Siberia and the Soviet Far East, where low energy consumption loads do not warrant the construction of thermal or hydraulic power stations or the switching of remote users into the operating power networks. In these regions it is possible to combine various types of renewable energy resources to meet user needs for electricity and heat.

BIOMASS AND ORGANIC WASTES

The use of biomass as a fuel is insignificant in the Soviet Union (about 60 million cubic meters or 15 million trf -- less than 1 percent of the total energy consumption).

Yet, in the past few years keen interest has been shown in the utilization of various organic wastes originating in industry, agricultural production and cities. This interest was first due to considerations of environmental protection and lately to the possibility of partially replacing high-grade liquid and gaseous fuels.

Of greatest interest in this connection is the process of anaerobic digestion of organic substances to reprocess them and obtain high-quality fertilizers and biogas (methane).

It is proposed that the residues from anaerobic digestion of wastes be used as primary material for obtaining protein-rich fodder additives. As distinct from developing countries, where biomass and organic wastes are utilized in small installations allowing the local problems of energy supply and employment to be solved, in the Soviet Union attention is focused on building large centralized plants.

The process of anaerobic digestion is used mainly in the Soviet Union in the treatment of sewage water sludge and the processing of agricultural residues.

The Anaerobic Treatment of Sewage Waters

The organic substances obtained from effluents discharged by the food and microbiological industries are a reserve for saving primary energy resources. The effluents of these enterprises are highly concentrated and require a special approach to neutralization and treatment. In the next few years, the construction of a large number of treatment facilities is planned at these enterprises. In most cases, treatment technology involves anaerobic digestion of organic substances -- their complete conversion into carbon dioxide and water without utilizing oxidation energy. More effective is the fermentation of methane during which the hydrogen and carbon of the oxidized substances do not react with oxygen, as they do during anaerobic digestion, but are expended on the generation of methane biogas.

The following data indicates the amount of methane that can be obtained by this method: A medium-capacity meat-packing plant produces 4,000 cubic meters of effluent per day. The yield of biogas per cubic meter is about 5 cubic meters. More than 20,000 cubic meters of fuel gas can be produced every day. A molasses distillery integrated plant produces effluents at the rate of 500 cubic meters. It is possible to obtain more than 10 cubic meters of gas from every cubic meter, or more than 5,000 cubic meters per day from one such enterprise. In the Ukraine alone there are more than 100 meat-packing plants and several dozen distilleries. Each of them can produce millions of cubic meters of gas per annum. Similar capabilities are available at sugar mills, starch and molasses mills, dairy plants and various enterprises of the microbiological industry.

The employment of the process of methane fermentation for industrial effluent treatment in combination with the existing method of anaerobic oxidation is not only possible but necessary. It assures a high degree of purification at lower costs, even if the utilization of methane and the biomass formed in the process is not taken into account. This is due to the fact that the concentration of organic impurities in effluents exceeds by dozens of times the values at which the existing aerobic method yields a sufficiently high economic gain. At high concentrations of organic substances, aerobic treatment results in increased costs caused by the growing oxygen demand and the need for secondary water treatment (recirculation). The employment of methane fermentation permits the concentration of the organic substances in runoffs to be lowered by 80 to 90 percent, and the advanced effluent treatment is easily carried out by the aerobic method. In that case, the total treatment costs will be substantially lower compared to costs involved in a purely aerobic process. For instance, the economic gain from the employment of the process of methane fermentation, within the scheme of waste water treatment at meat-packing plants, exceeds 400,000 roubles per annum for each enterprise. In utilizing methane forming in the process, which can replace high-grade liquid and gaseous fuels costing about 100 roubles per trf, the economic gain is increased to 900,000 roubles. Simultaneous utilization of the microbic biomass as a protein-vitamin concentrate for livestock feeding will permit savings of up to 1.5 million roubles per annum.

It is held that the use of anaerobic waste water treatment in industry could assure the production of 4,000 million cubic meters of biogas per annum, which is an equivalent of 3 million trf.

Of great interest is the use of anaerobic treatment of sewers in large cities. For instance, at the activated sludge plants in Moscow a total of 25,000 cubic meters of sludge is formed every day, with a moisture content of 97 percent and an overall volume of dry matter of 280,000 tons per annum. The whole amount of sediments is subjected to anaerobic sludge digestion in methane tanks. The amount of biogas evolving in the process is 10 to 12 cubic meters per 1 cubic meter of sludge. The biogas liberated in the process of digestion contains: 60 to 65 percent methane, 16 to 34 percent carbon dioxide, 0 to 3 percent nitrogen and 0 to 3 percent hydrogen. The normal calorific value is 5,000 kcal per cubic meter. The gross yield of biogas at the Moscow activated sludge plants amounts to 180 trf per day, or more than 60,000 trf per annum.

Biogas produced in the heated digestion (methane) tanks of the Moscow activated sludge plants is used to meet the energy needs of the city's sewage handling facilities.

The construction of activated sludge plants using anaerobic digestion of wastes only in large cities, each with a population of 1 million or more (such cities have a combined population of more than 35 million) makes it possible to produce at least .25 to .30 million trf per million people which, by present-day standards, amounts to 10 to 12 million trf per annum.

Anaerobic Digestion of Agricultural Production Wastes

Agricultural production is a large-volume producer of renewable energy resources as yet insufficiently utilized. These resources consist of the organic wastes of crop and livestock farming (straw, the tops of root-bearing plants, the stalks of cotton, maize and other plants as well as excrements and other organic wastes from agricultural production).

These wastes pollute the environment (especially sewage waters from livestock complexes and wastes from poultry farms). The direct introduction of these wastes into the soil as fertilizer entails significant losses of nutrient substances.

Modern microbiology has at its disposal technical solutions allowing a considerable reduction in the nutritive losses in fertilizers, helping to settle the question of the sanitary treatment of waste waters and allowing fuel to be obtained in the form of biogas. The basis of this technology is the digestion of organic wastes under anaerobic conditions by means of cellulose-fermenting and methane-producing bacteria.

Several designs for systems of anaerobic fermentation of agricultural residues have been produced in the Soviet Union. An integrated process scheme for treating waste water in discharge channels of livestock complexes is of interest. Under the scheme, wastes from the pens occupied by animals come to the sewage screens, then on to the press filters whence the residue squeezed out is routed to the dry feed shop, where it is mixed with activated sludge from methane tanks and is pelletized. The dry feed then is sent to fish-breeding complexes. One livestock complex is capable of producing annually a total of about 2,000 to 3,000 tons of dry feed saturated with biotin from the activated sludge of methane tanks. This allows 800 to 1,000 tons of fish to be bred on this feed.

The biogas forming in the methane tanks is collected into a gas-holder and utilized in heating and the steaming of feeds. Excess gas is used for the heating and production of feeding meal. A livestock farm of 5,000 head of cattle is capable of producing daily up to 3,500 to 4,000 cubic meters of methane through the digestion of 1,000 cubic meters of waste water.

An energy-supply scheme for a large agricultural complex and an urban-type settlement for the temperate zone has been drawn up. A comparison of this scheme with the long-established technology of organic waste utilization shows that out of a total of 68,900 tons of organic wastes with a moisture content of 75 percent which the farm obtains from crop and livestock farming, a mere 28,500 tons per annum are applied for fertilization. This means that under the established technology, a mere 43 percent of the starting amount of organic residues is applied as fertilizer. If all the organic residues and wastes were used as stock for the operation of a bioenergy plant, they could produce 63,800 tons of high-quality disinfected fertilizers and 4.4 million cubic meters of biogas with a total energy content of 3,400 trf. This energy would suffice to ensure all the heating processes for which the farm now uses natural gas and coal.

An analysis of the transportation costs involved in the delivery of organic residues from fields and farms to the bioenergy plant, and bringing the digested mass to the fields, has shown that given average haul distances of 12 kilometers the fuel consumption for these purposes does not exceed 20 percent of the energy derived from the biogas produced.

With regard to the farm considered above (4,360 hectares of plowland), costs for constructing a bioenergy generating plant with a storage facility of 70,000 cubic meters will total 1,260 roubles, with annual operation costs of 36,000 roubles. The plant will have the capacity to produce 220,000 tons of organic fertilizers and 4,038,000 cubic meters of biogas (3,173 trf), with costs for production and storage of 1 ton of organic fertilizer being 22 kopecks. For generation of 1 cubic meter of biogas the cost would be 1.8 kopecks per cubic meter (23 roubles per trf).

Higher capacity plants used on farms with 40,000 hectares of farmland will allow unit costs for fertilizer preparation and biogas generation to be cut by 20 to 30 percent, compared with the similar indicators of the bioenergy generating plant examined above.

In the long term, the utilization of the organic residues and wastes originating in industry, agriculture and the housing-and-communal sector is to become a reliable renewable source of energy. Its commercial utilization will make it possible to resolve the important problem of protecting the environment, obtaining millions of tons of high-quality fertilizer and saving significant quantities of liquid and gaseous fuels.

FOOTNOTES

1 N. A. Maltsev. New Frontiers of the U.S.S.R. Oil Industry. (In Russian). "Neftyanoye Khozyaistvo" (Oil Economy), 1979, No. 9, p. 7.

2 M. A. Berstein, et al. Employment of Different Methods for Increasing the Recovery of Oil Pools. Moscow, 1977, p. 14, p. 22.

3 A. B. Vol-Epstein. Thermal Dissolution of Oil Shales and Coals. (In Russian). "Khimiya Tverdogo Topliva", 1980, No. 6.

4 Reference fuel = 7,000 Kcal per kilogram.

5 In some cases, it is expedient to use wind-generated installations for water elevation and electricity supply.

6 Due to heat storage by the hothouses and the possibility of lowering the hothouse temperature below the optimal one.

Sri Lanka

CONTENTS

TABLES

INTRODUCTION

In Sri Lanka, the availability of hydro resources has, to a large extent, inhibited the immediate exploitation of the other alternatives. Nevertheless, electricity generation from non-hydro resources would be needed in the 1980s to meet the emerging gap between electricity demand and supply. It is therefore necessary to examine the new and renewable energy resources that may be relevant to Sri Lanka.

Energy is most definitely a central component of any nation's development strategy. As much as 34 percent of the investments in the Five-Year Investment Program (1981-1985) of the present government is in the energy sector. The net import of petroleum products in 1980 constituted as much as 36 percent of the total exports of the country during that year, although this met only 27 percent of the country's total energy needs. Seventy-three percent of total energy used came from the renewable energy resources. With the liberalization policies adapted by the government since 1977, the demand for energy, both petroleum and electricity, has been rising very dramatically. The cost of net petroleum imports during 1981-1985 is expected to be in the region of Rs. 60,000 million (U.S. $3,500 million). Hydroelectric supply would have to be supplemented by thermal electric sources to bridge the gap between electricity demand and supply -- a gap that already has emerged and will widen very rapidly toward the end of the century.

It is therefore imperative that the remaining hydro resources would have to be exploited in full. Pricing policies and conservation of oil through pricing and use would have to be introduced. A planned reforestation program has to commence without delay, and renewable energy resources have to be exploited. The role the renewable energy resources could play should primarily be assessed by monitoring solar, wind and biomass throughout the country. At present, there is no systematic monitoring of these sources. Efficient domestic stoves should be marketed. The use of fluorescent lights should be encouraged. Transport consumes 50 percent of imported oil. Consumption of oil in transport

Notes: 3 GWh electrical energy has been taken as equivalent to 1,000 tons of oil equivalent.
1.6 tons coal has been taken as 1 ton of oil equivalent.
1 ton fuel wood has been taken as .42 ton of oil equivalent.

warrants the improvement of the railways and shift from roadways to railways in the mass transportation of goods and people. In order to meet the energy needs of the decades 1981-1990, 1991-2000 and 2001-2010, each of which is slightly different in nature, measures have to be taken simultaneously and immediately to avert serious impediments to development programs.

The importance of these tasks has been fully appreciated by the government and programs have been or are being prepared to implement them. The establishment of the Natural Resources Energy and Science Authority, which is to be constituted by the president of Sri Lanka and directly responsible to him, as well as the recent takeover by the president himself of the Portfolio of Power and Energy, will be the start of an intensive and coordinated energy development program in Sri Lanka.

THE ENERGY SCENE IN SRI LANKA

Sri Lanka has an area of about 65,600 square kilometers. The annual rainfall varies from less than 100 centimeters in the dry zones in the northwest and southeast sections of the island to 500 centimeters at certain places in the northwestern slopes of the hills. The relative humidity varies generally from about 70 percent during the day to about 90 to 95 percent at night. The country is blessed with sunshine throughout the year, with an average solar insolation of about 5 KWh per square meter per day.

The population of Sri Lanka was 14.86 million as of March 1981. The average rate of growth in the past 10 years has been 1.7 percent per year. About 76 percent of the population lives in the rural areas, where the main activity is agriculture. The per capita GNP in 1979 was Rs. 3,424 (U.S. $220), at current prices.

The year 1977 saw a rather dramatic change in the economic policy, reflecting the liberalized policies of the United National Party Government, which took office in 1977 under the leadership of His Excellency Mr. J.R. Jayewardene. The economy recorded a growth rate of 8.2 percent in 1978, although the growth rate fell in 1979 to 6.2 percent and in 1980 to 5.6 percent. Domestic savings reached 15 percent of GNP in 1978 and 1979, well above previous levels. Private and public investments grew rapidly, bringing the total investment to 20 percent of GNP in 1978 and 25 percent in 1979. The government embarked on three major new lead projects in the five-year rolling public investment program between 1980 and 1985. These are:

- The Accelerated Mahaweli Ganga Development Program for hydro power, irrigation and land development, self-sufficiency in food, human settlement and employment.
- The Greater Colombo Economic Commission for Industrial Development and Export Productivity.
- The islandwide housing development program, commencing with the massive Urban Development Program around Colombo City.

The total energy consumption in Sri Lanka in 1979 was estimated at 3.5 million tons of oil equivalent, of which 60 percent came from fuel wood and agricultural residues, 27 percent from petroleum products and 13 percent from hydro-electricity. Reliable estimates indicate that of the 60 percent of non-commercial energy consumption, almost two-thirds comes from fuel wood while one-third comes from the agricultural residues.

The sectoral composition of energy consumption, expessed as a percentage of oil equivalent, was as follows:

	Total Energy	Commercial Energy	Petroleum Products	Electricity	Fuel Wood & Agricultural Residues
Domestic	52.9	22.4	23.8	21.6	74.0
Transport	13.4	32.8	50.5	-	-
Industrial	29.2	34.0	19.0	67.1	25.9
Losses	4.5	10.8	6.7	11.3	-

The principal commercial sources of energy in the Sri Lanka economy are oil, electricity and relatively small quantities of coal. In certain small industries (such as brick and tile making, smoked rubber, dessicated coconut and coconut oil production and tobacco curing), as well as in the domestic sector, traditional fuels -- fuel wood and agricultural waste such as bagasse -- also are used.

Table 1 sets out details of commercial and non-commercial energy consumption during the period 1960-1979 in tons of oil equivalent.

There has been a gradual phasing out of the use of coal, from 20.5 percent of commercial energy use in 1960 to almost zero in 1979. The percentage use of hydroelectricity has increased from 11.1 percent of total commercial energy demand in 1960 to 33.4 percent in 1979. The percentage use of petroleum products in total commercial energy consumption has remained at about 70 percent during 1960-1979, with the highest recorded (80.5 percent) in 1973. Fuel wood and agricultural residues have remained a major non-commercial source of energy, providing almost 60 percent of total energy consumption in the period 1960-1979, almost two-thirds of which was contributed by fuel wood.

Following the acceleration in economic activity in all sectors of the economy and relaxation of import controls on vehicles and electrical appliances, the demand for energy, both petroleum-based and electrical, has grown rapidly during the past two years. There is, however, very little hope for reducing the country's dependence on imported petroleum during the medium term.

Electrical Energy Consumption

In 1979, 1,525 GWh of electrical energy was generated and the peak demand was 328.9 MW. The per capita consumption of electrical energy was 89.6 KWh for 1979. In 1980, 1,666 GWh of electrical energy was generated and the peak demand was 368.5 MW.

Electricity serves only 11 percent of the households and 8 percent of the villages. About one-quarter (350 MW, 1,600 GWh) of the hydroelectric potential already has been harnessed, and plans are in progress for the harnessing of about another one-quarter (600 MW, 1,500 GWh) under the Accelerated Mahaweli

Development Program. The remaining half (1,000 MW, 3,200 GWh) is to be exploited in quick succession in the 1990s. Thermal power generation still will be necessary to supplement hydro resources to meet the widening gap between electricity demand and supply. Steam plants with an effective capacity of 40 MW and diesel plants with an effective capacity of 10 MW have been installed. Last year, three gas turbines of 60 MW capacity were installed and this year another three gas turbines of 60 MW capacity are being installed. These plants use expensive diesel fuel. The next thermal additions are expected to use furnace oil.

As much as 98.3 percent of electricity generated in 1975-1979 was from hydroelectricity. This percentage dropped to 88.7 percent in the year 1980. The share of thermal power generation is expected to rise in the 1980s.

It is thus seen that 73 percent of the energy consumption in 1979 was from the renewable energy resources, while 27 percent came from petroleum products. The cost of the latter was 36 percent of the total exports in that year.

Little can be done to replace the 13 percent of total energy (or 50 percent of petroleum products) consumed in the transport sector unless the railways are properly managed, although there could be considerable replacement by renewable resources in the 14 percent of total energy (in the form of petroleum products) consumed in the domestic and industrial sectors.

The increase in demand for total energy should therefore be met by increasing the efficiencies in utilizing the renewable energy sources, and systematically replacing petroleum use in the domestic and industrial sectors by the renewable energy resources.

INSTITUTIONAL ARRANGEMENTS

The Ceylon Electricity Board is the authority for the generation, transmission and distribution of electricity on the island. The Ceylon Petroleum Corporation is responsible for importing, refining and distributing petroleum products in Sri Lanka. The Department of Conservation of Forests is responsible for the management of the forests, while the harvesting of timber is the responsibility of the State Timber Corporation. The Development Planning Unit (sponsored by the United Nations Development Program) in the Ministry of Finance and Planning had initiated some exercises toward the development of an energy policy in Sri Lanka. Some important energy issues were discussed at a well-attended seminar, "Toward an Energy Policy in Sri Lanka," in November 1977, jointly sponsored by the Development Planning Unit and the Ceylon Electricity Board. Largely as a result of these recommendations, the cabinet appointed a committee to report on steps to be taken to meet the short- and long-term energy needs of the country. Consequent to the recommendations of the committee, the cabinet has approved the establishment of a Natural Resources, Energy and Science Authority, which is to be constituted by the president of Sri Lanka and directly responsible to him. This authority, which will absorb the present National Science Council of Sri Lanka, as well as the recent takeover by the president of the Portfolio of Power and Energy, will be the start of an intensive and coordinated energy development program in Sri Lanka.

ENERGY DEMAND PROJECTIONS

The projections for electrical power and energy demand is regularly updated by the Ceylon Electricity Board. The rapid increase in the electricity demand after the government took office in 1977 has lead to electricity demand projections being revised almost monthly.

Table 3 indicates the electricity demand projections as of June 1981.

It is clear that along with the commissioning of newer hydroelectric projects, large additions of thermal electric sources would be needed to meet the rising demand for electricity.

RURAL ENERGY ISSUES

The sectoral consumption of fuel in the rural sector has been analyzed in the Socio-Economic Survey of 1969-1970.

The survey reveals the pattern of fuel use as follows:

	Number of households using fuel for			
	Cooking		Lighting	
	In '000	%	In '000	%
Electricity	0.0	0.0	48.69	2.9
Gas	0.0	0.0	1.93	0.1
Kerosene	29.25	1.9	1,451.63	96.7
Fuel Wood	1,472.84	97.9	4.33	0.3
Others	2.31	0.2	0.48	0.0

We observe that the major fuel for lighting is kerosene and for cooking is firewood.

Although the Ceylon Electricity Board has been actively pursuing the electrification of the rural sector through the rural electrification program, the total number of households using electricity remains very low. Only 1,915 villages out of a total of 23,617 villages have access to the electricity grid. This constitutes 8 percent of the villages. However, 122 out of 195 urban centers (63 percent) have access to electricity. Five percent of the rural population has access to electricity.

The Ceylon Electricity Board electrifies about 200 to 300 villages per year, catering to about 10,000 rural households. Against this spread of electrification, more than 30,000 new households come into existence each year due to population increases. The major hindrance to rural electrification schemes is that it has been impossible to find any scheme giving an overall return of more than 4 to 5 percent. Although the financial return due to the high cost of construction is no more than 4.5 percent, the social benefits that are given to the rural sector in the process have encouraged the government to provide electricity to as many villages as permitted. Rural electrification programs are financed by a government grant, the decentralized budget and the Ceylon Electricity Board.

A bank's loan scheme has been introduced to assist those who are unable to meet the initial capital investment required for electrical installations in their households. The current proposals for rural electrification are in the region of Rs. 500 million but they have been phased out of the 1981 budget due to financial restrictions. Rural electrification constitutes about 3 percent of the total demand.

The social and economic benefits of rural electrification should be properly assessed in the present context of energy supply and demand, particularly electricity provided for rural lighting only. Efforts should be made to use electricity for direct productive activities in the rural sector. Rural electrification schemes should be designed and selected as part of a comprehensive rural development program.

It also should be remembered that any energy plan must be viewed in the overall context of meaningful improvement in the standard and quality of life of the people. This plan must be viewed within the context of the social, economic and cultural factors which are the ultimate determinants of energy demand.

In this country, the majority of the population is connected to the rural agricultural economy. The country faces the problems of rural development for the majority, who are still living at levels below the basic needs, namely:

- A minimum requirement of private consumption (food, clothing and shelter).
- Access to communal services (drinking water, sanitation facilities, public transport, health and educational facilities).
- Adequately productive and fairly remunerative employment.

The basic lighting requirements for the rural household that has no access to electricity should be provided by guaranteeing an adequate supply of kerosene.

It has been observed that, on an average, a household of six would require 1.8 gallons of kerosene per month to meet the basic requirements of lighting and cooking. This is probably the amount now consumed by households that do not have access to electricity. This supply has to be guaranteed by issuance of coupons to the identified households not having electricity as they may not be able to face the cost of escalating kerosene prices. This facility should be withdrawn from households that have access to electricity.

The progress of domestic agriculture displaces more and more labor, which should be absorbed in industries that are associated with agriculture. Industrial development calls for the utilization of energy.

ENERGY RESOURCES

Forest Resources

The demand for fuel wood and agricultural wastes will be governed by its supply. The fast dwindling of forest resources will have to be arrested, and a planned fuel wood program will have to be maintained during this decade to recover the forest cover lost during the past 20 years.

According to a survey of the forest area in 1956, a forest cover of 2.88 million hectares was identified. Recent estimates of forest cover is in the region of 1.6 million hectares. Although illicit felling of timber had been known to take place for a very long time, serious thoughts on protecting the dwindling forest resources have emerged only recently.

The use of fuel wood and agricultural wastes has been estimated to gradually increase from about 4 million tons per annum in 1960 to about 5.2 million tons per annum in 1980. The Forest Department estimates fuel wood consumption at about 3.5 million tons per annum in 1980. The natural regeneration of fuel wood from the forest cover cannot exceed 1 million tons per year. The fuel wood from the rubber plantations, which cover a little more than half a million acres, has been estimated at .3 million tons per annum. The residues from coconut wastes, paddy husks, saw mills and from crop residues, including rubber wood, would yield about 1.5 million tons of fuel wood per annum. The remainder could be assumed to be derived from the denudation of the forests.

Recent studies on fuel wood use in Sri Lanka indicate that about 5 million metric tons (MT) of fuel wood and agricultural residues is currently used per annum.

A hectare of natural forest, when denuded, is expected to generate 170 cubic meters of wood, of which 20 percent may be assumed to be used as fuel wood. The annual harvest from a natural forest may be assumed to be 2 percent of this capacity.

It has been estimated that the fuel wood requirement during 1956-1980 has been in the region of 96 million tons. Of this, 36 million tons is estimated to come from accretion of crop residues (including rubber wood), 27 million tons from natural regeneration of forests, and 35 million tons from the denudation of forests.

It becomes clear that it will no longer be possible to maintain the use of about 5 million tons of fuel wood per annum without embarking on a planned reforestation program. The indiscriminate felling of trees in the catchment areas in the central hills has to be controlled, because it otherwise would affect the regular inflows into the reservoirs for precipitation.

The Forest Department has renewed its measures to protect the forest resources in order to maintain a healthy ecological balance. The Forest Department recognizes that sufficient forests must exist to ensure:

- Regular flow of water in streams.
- Prevention of soil erosion.
- Amelioration of the climate and development of the environment.
- Sustained supply of timber and firewood to meet part of the local market.

At present, only 9 percent of the Wet Zone region is under forest cover when it should be 25 percent. The Forest Department recognizes that the existing forest cover in the Montane Zone above 1,500 meters should not be exploited for any purpose and hopes to increase the Dry Zone forest cover to 25 percent of the land area.

Among the strategic objectives of the Forest Department are:

- Annual reforestation of derelict forest lands and unproductive lands in the Wet Zone and the Dry Zone, extending from 2,400 and 4,800 hectares in 1981 to 3,200 and 6,000 hectares in 1983.

- Reforestation of neglected tea and rubber lands in the Wet Zone and Intermediate Zone at the rate of 600 hectares per annum from 1981 to 1983.

- Reforestation of the Upper Mahaweli Catchment area at 1,200 hectares per annum.

- Fuel wood plantation in the Mahaweli settlement area at 2,800 hectares per annum.

- Protection of 1.6 million hectares of forest lands.

These objectives have been recognized by international organizations and friendly countries that have lent support.

The Forest Department's 1979 plan to reforest 7,200 hectares in 1981 under its normal reforestation program has been stopped because the funding requirement of Rs. 17.5 million has been reduced to Rs. 6 million, resulting in inability to execute normal reforestation programs. The cost of importing crude oil to meet the scarcity in fuel wood due to delayed reforestation could exceed the Rs. 11.5 million gained by the cut imposed on the Forest Department.

At the present rate of consumption of firewood, the forests are being rapidly denuded. Even to maintain the present levels of consumption of firewood, a planned reforestation program is vital. The supply of crude oil is getting more expensive and scarce day by day. Yet it will not be easy to replace oil as a transport fuel. Substitutes for oil therefore will have to be found in other sectors. In spite of the very sincere efforts that are being made to expedite the construction of certain hydro power projects to be commissioned on schedule, there may be significant delays. Such delays would become unavoidable if adverse soil conditions or climatic conditions are faced during the course of construction work. It has been observed that owing to the liberalized policies of the government, the demand for electricity has been growing at a very rapid rate since 1977. If demand patterns continue to grow at these rates, the need for new sources of energy to supplement the demand for electricity would arise within a few years.

The New and Renewable Sources of Energy

Solar radiation, wind, biomass and micro-hydroelectric resources are generally freely available and require some capital investment in hardware for collection and conversion into useful forms. These technologies are highly developed, mainly in the developed countries, with the probable exception of biomass. Due to low demand, the cost of these processes is still high.

A certain amount of research and development work has been done in the context of the conditions and needs of the developing countries. The technologies developed within the framework of the social and economic limitations of the community can contribute to a healthy rural development program.

The main energy resource in Sri Lanka is sunlight. Some 50 billion tons of oil equivalent in sunlight falls on Sri Lanka every year. Fuel wood and agricultural wastes, (which constitute almost 60 percent of total energy consumption) are derived through photosynthesis, while hydroelectricity (which constitutes almost 13.3 percent of the total energy requirements) derives its energy from rainfall. Almost 26.7 percent of total energy consumption is obtained from oil imported to the country either in the crude form or as refined products. Sri Lanka does not have known deposits of coal, oil or natural gas. There are a few deposits of peat and mineral deposits containing uranium and thorium ores.

There are 109 rivers and streams, mostly originating from the central hill country, each having varying drainage areas ranging from 4 to 4,000 square miles. The total annual rainfall over the entire island is estimated to be 107 million acre/feet. The runoff into the sea from all rivers and streams has been estimated differently at different periods of time and depicts a minimum estimate of 30 million acre/feet and a maximum estimate of 41.6 million acre/feet.

Existing hydro resource potential has been estimated at about 2,000 MW with an annual energy capability of about 6,600 GWh. Of these, a potential of 369 MW with an annual capability of 1,608 GWh already has been harnessed. The Accelerated Mahaweli Development Program is expected to harness another 640 MW power and 1,834 GWh annual energy during this decade. Hydro power will continue to be the major source of electricity until the late 1990s with the development of Samanalawewa (240 MW, 400 GWh), Upper Kotmale Oya (100 MW, 300 GWh), Uma Oya (100 MW, 375 GWh) Kaluganga (150 MW,450 GWh) and other relatively less attractive projects.

Peat Resources

The only significant resource identified so far is the peat at Muthurajawela, which is a relatively small deposit. The United Nations Development Program team, which assessed the hydroelectric potential in the Mahaweli Scheme in 1968, mentioned that the peat at Muthurajawela amounted to about 50 million tons. The availability of peat in other areas has not been assessed comprehensively. It would be desirable to have a reassessment of the resources. Considerable enthusiasm was generated to utilize the peat resources in the country when it was discovered that large areas in the neighborhood of Colombo had become uncultivable due to salinity, and once-fertile land was fossilizing into peat bogs.

A peat bog running into 2,200 hectares, situated 10 kilometers north of Colombo, known as the Muthurajawela peat bog, was examined by a Russian team in 1960. On analyzing an area of about 1,500 hectares it was observed that 460 hectares have a peat bed 2.1 meters thick and no more than 30 percent ash. The quantity of the peat resources of this kind is estimated to be about 10 million cubic meters. If .6 of this peat is recoverable and the output of peat is .42 tons per cubic meter, the total tonnage of recoverable peat amounts to about 3 million tons of peat containing 40 percent moisture. The remaining part of the territory, covering 1,000 hectares, contains shallow peat or a bed inlaid with minerals and drifts, with an ash content reaching 45 to 50 percent. These beds are unfit for the extraction of peat.

The peat field is of the low moor type and the contents are mainly of the herbaceous and tree type. Aluminum and silicon predominate in the ash of peat. The peat has a high content of chlorine, magnesium and sulfur. Chlorine and magnesium are due to the ocean floor waters. Sulfur is due to the activity of aerobic bacteria as well.

The peat may be dried in the open air to attain a moisture content of 40 to 50 percent and a heating value of 2,600 kcals per kilogram to use as industrial fuel. Two million tons of this peat could generate 1,500 GWh of electrical energy.

For domestic purposes, peat may be turned into briquettes containing 15 percent moisture with a calorific value of 5,600 cals per gram. The peat may also be used to produce gas, to make alcohol, furfural, exalic acid, liquid carbonic acid, various kinds of peat fertilizers and insulating plates.

Prospects for Solar Energy

Photovoltaic cells for direct conversion of solar energy into electricity are expected to come down in price within the next decade. The technology of photovoltaics cannot yet be accommodated in a rural economy. It may be used to power VHF radio links between remote post offices and rural exchanges. Solar panels for heating and cooling buildings may interest those who have no access to power for heating and air conditioning from a central electricity grid, such as rural health centers and hospitals. Conversion of solar energy into thermal energy and thence to electrical energy has not yet been proved to be adaptable into a rural economy. Low-cost solar stills could provide potable water to rural households in areas where well water is brackish, and provide distilled water for car batteries and rural science laboratories. Solar driers will be useful for the quick drying of agricultural products and fish under hygienic conditions.

The feasibility of using solar stills to produce fresh water, driers for crop drying, water heaters and cookers have been examined by the Ceylon Institute for Scientific and Industrial Research, the engineering faculties of the Universities at Peradeniya and Moratuwa, the National Engineering Research and Development Organization and the Ceylon Electricity Board.

Wind Energy

Wind energy is best utilized for lifting surface water, extracting ground water and running sailing boats on the seas. The best wind potential has been found in the Hambantota area (southeast) and the Jaffna area (north). Except for the southwestern parts of Sri Lanka, in the other parts of the island where there is a good wind potential, the dry season coincides with the high wind period, which makes it very attractive to use windmills for water pumping. Historically, windmills were built in the Dutch times (1658-1796) at the forts at Galle, Hambantota and Hammond Heil. The government of the Netherlands has assisted in setting up a Wind Energy Unit in Sri Lanka on the initiative of Mr. P.T. Smulders and Mr. A.D.N. Fernando, to design and test small-scale water pumping windmills and to promote manufacturing and the utilization of windmills. This unit, presently attached to the Water Resources Board, has successfully designed and constructed two prototype windmills now under testing in Colombo.

In recent times, several attempts have been made to use windmills for lift irrigation, electricity generation and to pump saline water to the salterns. The engineering faculties in the universities at Peradeniya and Moratuwa and the National Engineering Research and Development Organization have been conducting some research in these areas. They have not been field-tested yet. The main reason for their failure was their unsuitability for the wind regime that existed in that region.

The use of wind energy for electricity generation is possible in the Hambantota region, and in certain parts of the hill country, including the Matale Valley, the Haputale gap, the Ella gap, Horton Plains, Hunnasgiriya, Madugoda, Corbett's gap, Umbugal and the Ginigathhena pass.

Although there are 500 stations to monitor rainfall, there are only 16 meteorology stations and 17 agro-meteorology stations to monitor wind regimes. The anemometers are installed at heights of 6 meters above the ground at the meteorology stations and at 1.5 meters above ground at the agro-meteorological stations.

The objectives of a wind energy program should be directed at the building up of an anemometer network (preferably at the internationally accepted height of 10 meters) in Sri Lanka and the windmill design to be in keeping with the wind regime.

Biomass

The use of biogas generators in recycling animal, agricultural and municipal wastes for the generation of methane and production of a higher value fertilizer has its applications in Sri Lanka. Various types of biogas generating and utilizing systems have been tested at the University of Peradeniya. The Ceylon Electricity Board, the Industrial Development Board and the Department of Agriculture have programs for the popularization of biogas generators. The Indian design and the Chinese design have been popularized, and it is estimated that there are more than 300 biogas generators currently installed in Sri Lanka.

Fuel Wood and Charcoal

Fuel wood is used in the domestic sector, in tea factories, brick and tile industries, bakeries, for tobacco curing and in similar endeavors.

Charcoal became popular for domestic consumption in April 1980, and to date there are about 6,000 charcoal stoves. Charcoal consumption is about 30 tons per month.

The normal domestic fuel wood hearth uses fuel wood at about 14 percent efficiency. Improved stoves, which have efficiencies in the range of 20 to 25 percent, have been developed by the Ceylon Institute for Scientific Research and the Industrial Development Board. The Institute for Scientific Research design is a prefabricated modular stove which costs about $2.

The institute has developed several charcoal stoves currently sold by the State Timber Corporation. The low-cost wood stove is being field-tested, and popularization may be possible toward the end of this year.

At least 250,000 hectares of fuel wood plantations are estimated to be needed by the year 2000.

Gasification or pyrolysis of wood charcoal or briquetted paddy husks and coal dust is being examined.

A recent study indicates that paddy husk can cater to the heat energy requirements of the entire rubber, dessicated coconut and tobacco industries as well as part of the tea industry. The cost of paddy husk briquettes per unit as energy delivered is much lower than that of coal, electricity or oil, and about 1.25 times that of fuel wood.

Ocean Thermal Energy Conversion

A recent study by the National Science Council of Sri Lanka has shown that Sri Lanka could possess sites favorable for ocean thermal energy conversion plants. However, a systematic investigation of the coastal region to map out temperature and depth profiles is a preliminary requirement. A large-scale project for Sri Lanka cannot, however be recommended at the present stage.

Mini-Hydro Development

Some tea estates, which had been using mini-hydro plants before the advent of cheap oil resources, abandoned these plants in favor of diesel generators. About 3 MW of power capacity from abandoned mini-hydro plants can be recovered by upgrading and repairing machines already installed in the estates.

However, the economies of developing a new mini-hydro scheme should be evaluated against the development of larger hydro resources still undeveloped.

Geothermal Energy Resources

There are a few hot springs in Sri Lanka, but the energy in them is not sufficient for commercial exploitation. There is, however, a suspected geological fault running across some parts of the island. An investigation into this geological fault may throw some light on possible sources of geothermal energy.

THE RURAL ENERGY CENTER

The United Nations Environment Program at the third and fourth meetings of its Governing Council decided "to accord high priority to the establishment in some of the typical rural areas of the countries of Asia, Africa and Latin America of a few demonstration centers harnessing individually or in combination the renewable resources of energy locally available."

The decision to have the Asian Demonstration Center in Sri Lanka was welcomed by the government. A site having plenty of sunlight, strong winds and animal and agricultural wastes, bordering an existing natural lake, was selected to the satisfaction of program authorities and their consultants. The average solar insolation has been estimated at 5 KWh/sq.m. per day with an average wind regime of 12.3 m.p.h. at the site. The project envisages harnessing the three renewable sources (solar, wind and biomass energy) in an integrated manner to produce electricity for lighting the houses, pumping drinking water and providing motive power for cottage industrial growth for as many families of the Pattiyapola Village as possible (about 200), living within a radius of 1.5 miles (2.4 kilometers) of the site. The system is to make available annually about 60,000 KWh of electrical energy at 230 volt AC for the consumers. The costs of the various components were estimated as follows:

• Solar (rated 10 to 20 KW capacity)	U.S. $55,000
• Wind (rated 20 KW capacity)	$26,000
• Battery bank (300 KWh per day)	$25,750
• Biogas (rated 50 KW capacity)	$23,250
• Power distribution	$12,500
• Overhead tank of 3,000 gallons	$15,000
• Water purification plant	$5,000
• Meteorology observatory	$3,000
• Miscellaneous, including contingencies	$20,000
• Consultants (three trips to total six weeks)	$12,000
• Training two local engineers for three months	$5,000
	U.S. $202,500

$160,000 Foreign
$ 42,500 local

A project agreement was signed between the Sri Lanka government and the United Nations Environment Program in September 1976, with the Ceylon Electricity Board as the executing agency, to have the demonstrating center operational by November 1978 with the U.N. group contributing U.S. $191,000 and the Sri Lanka government contributing U.S. $42,500 in local currency.

The United Nations consultants have, from time to time, made changes due to improvements in technology, and the project was later expected to be operational in June 1979. The U.N. group also has enhanced its contribution by U.S. $105,000 to U.S. $296,000. The Ceylon Electricity Board spends about U.S. $3,000 per year in local currency to maintain its staff at the site.

The objective of the project is "to demonstrate the technical, economic and social feasibility of harnessing solar energy, wind energy and biogas energy to meet the energy needs of a remote village and to prove that the existing state of the art of appropriate technologies for harnessing renewable energy resources under the conditions prevailing in rural areas of developing countries could justify the use of such technologies."

The project is composed of a wind electric system, a solar electric system based partly on thermal power generators and partly on photovoltaic generators and a biogas plant. The electricity produced by the three systems will be stored in a battery bank, transformed to 230 volt AC and distributed in the conventional manner. The proponents of this system have claimed that, if successful, the concept would revolutionize the lifestyle of no fewer than 800 million people living in small isolated village conditions in developing countries of Asia, Africa and Latin America.

The project is reaching its final stages. At the request of the United Nations Environment Program, a standing committee consisting of meteorologists, social scientists, engineers and economists working in Sri Lanka institutes and government departments has been appointed to monitor the progress of the center. The standing committee did not meet after the Ceylon Electricity Board was requested to execute the project, but is expected to be meeting very soon to evaluate the project.

TABLE 1. ENERGY CONSUMPTION
(In 1,000 tons of oil equivalent)

	1960	1965	1970	1975	1979
Coal	160	92	12	4	0
Petroleum Products	535	620	893	964	980
Hydroelectricity	87	122	247	359	487
Fuel Wood & Agricultural Residues	1,655	1,796	1,756	2,112	2,187

TABLE 2. ANNUAL GROWTH RATE OF ELECTRICITY SALES, 1960-1979

Period	Annual Growth Rate on Electricity Sales Total (%)	Domestic Sector	Industrial Sector
1960-1965	10.3	10.1	10.5
1965-1970	13.5	7.4	15.5
1970-1975	8.2	7.9	8.5
1976	3.1	7.7	0.6
1977	4.4	8.6	3.1
1978	11.6	10.1	12.1
1979	11.6	16.3	10.2
1960-1979	10.0	8.9	10.4

TABLE 3. ELECTRICITY DEMAND PROJECTIONS
(As of June 1981)

Year	1979	1981	1983	1985	1990
Total Generation (GWh)	1526	2140	2712	3529	5399
Hydro Generation (GWh)	1461	1550	1750	2507	3534
Thermal Generation (GWh)	63	590	962	1022	1865
Maximum Demand (MW)	328.9	452	573	744	1139
Hydro Capability (MW)	313	353	383	623	925

Thailand

CONTENTS

INTRODUCTION

Energy demand has been rising rapidly since the commencement of the first five-year economic development plan. In 1961, the energy consumption was 1,765 million liters of crude oil equivalent. The share of crude oil sources of energy was 78 percent. In 1971, the end of the second five-year economic development plan, the energy consumption was 7,695 million liters of crude oil equivalent. The share of crude oil sources of energy was 83 percent.

Almost all crude oil sources of energy had to be imported. The amount increased five-fold, but the cost only three-fold during 1961-1971. The import of crude oil sources of energy was 16 percent of the total export earning in 1971.

In 1981, the end of the fourth five-year social and economic development plan, the energy demand is estimated at 18,724 million liters of crude oil equivalent. The share of crude oil sources of energy will be 76 percent. The import of crude oil sources of energy will increase from 16 percent in 1971 to 37 percent of the total export earnings in 1981. This is affecting the economic and social system of the country severely, causing large payment deficits, inflation and income distribution problems. The situation will be much more severe during the fifth five-year social and economic development plan, starting in 1982.

Problems

The problems the country is facing in the energy fields are dependent not only on crude oil and its products but also the foreign exchange to procure them. The country spent more than one-third of its foreign exchange earnings to procure crude oil and its products in 1980. Moreover, the government has set a high priority policy to develop the rural areas where development has not yet reached. The energy demand for agricultural production and small-scale industries in the rural areas will be in addition to the need for cooking, lighting and other amenities. This will exert an increasing demand for energy, and much of the demand will have to come from crude oil sources unless positive steps are taken to introduce alternatives. The traditional use of fuel wood and charcoal for cooking in particular is already seriously affecting forestation. It is estimated that less than 25 percent of the land is left as forest land.

Policies

The government of Thailand has realized the situation and has put more emphasis on the development of new and renewable energy sources. The general policies pertaining to these can be summarized as follows:

- The development of new and renewable energy sources is a key to national survival and no efforts should be spared to reduce dependence on imported energy.

- The development of new and renewable energy sources should serve people throughout the country.

- The investigation and planning, research and development of utilization of new and renewable energy sources are fully encouraged and supported as far as possible.

- Private sectors and state enterprises are urged to commercially fabricate proven and acceptable energy-producing facilities using local skills and materials.

- Promotion of cooperation with other nations, and sub-regional, regional and international organizations is encouraged for the exchange of information, personnel and technologies.

Energy Strategies

The strategies for harnessing conventional sources where technologies are commercially available are divided into six main tasks, as follows:

- Investigation, exploration and interpretation of energy resources.
- Planning, starting from project identification, formulation and approval.
- Preconstruction design specifications and estimates.
- Construction, installation and test runs.
- Operation and maintenance.
- Evaluation.

In the case of nonconventional energy sources, the tasks are divided into six main categories, as follows:

- Resource assessment: This task includes evaluating new and renewable energy resources, the status of each energy resource use, the availability of energy resource data and determining other resources that can be developed to benefit the rural area.

- Investigation of needs: This includes the determination of energy requirements for basic needs and development needs, together with the requirements for the development of locally available resources other than energy resources.

- Research and development of relevant energy technologies: This includes setting up priority research and development areas in each new and renewable energy source, performing research and development in the areas selected and linking the research and development accomplishment to development and demonstration tasks.

- Development and demonstration of proven energy technologies: The prime focus of the task would be to set up a proven technology testing site to check technical performance and reliability.

- Demonstration and extension/promotion: Demonstration of proven, reliable technology will be carried out at several selected sites. The cost, based on use of locally available skills and materials, will be determined. If the technology is accepted by the people, extension/promotion will continue through government limited subsidies by providing component hardware or equivalent reimbursable cash for materials.

- Extension/promotion and popularization: The promotion of the proven and reliable technology will be amplified to the large scale as the technology is satisfactorily accepted, popularization through various means will be performed, and training will be arranged and supported.

The tasks outlined above would provide information including facts and figures for wide-scale development and utilization of new and renewable sources.

POTENTIAL OF NEW AND RENEWABLE ENERGY SOURCES

Hydro Power

Hydro power in the country has a potential to generate as much energy as 17,304 gigawatt hours (GWh). The current developed capacity is 1,270 MW, generating electricity at an average of 1,751 GWh in 1980. Micro-hydro potential capacity in Thailand is estimated at 1,066 MW of firm, dry-season unregulated power.

The term "micro-hydro" refers to a hydro power unit smaller than 100 KW in capacity. Development of the full potential of such dispersed resources is questionable. If 5 percent, or 50 MW, of the potential is considered as practical for development, more than 500 micro-hydro projects can be expected to be developed in this country.

The National Energy Administration, a governmental organization responsible for this development has found that cross-flow turbines and impulse turbines are most appropriate for rural development projects. At present, these types are being manufactured locally while the sophisticated and high-cost governors are still ordered from abroad.

Charcoal and Fuel Wood

Fuel wood still plays an important role as the principal cooking fuel in rural and urban areas. The demand for fuel wood in 1979 was 30 million to 40 million cubic meters. Recent estimates based on land satellite imagery put the total forest area close to 25 percent of the total land area, and it is estimated that, should the trend continue, the supply from natural forests will decrease to the level of 14 million cubic meters in 1985.

Biomass

Bagasse is produced and used predominantly (85 to 90 percent) by sugar industries as a heat source, which shares in an aggregated energy consumption of about 8.2 percent in 1979.

Paddy husk is used (55 to 60 percent) in rice mills, where it originates, as a heat source and also for cooking and making charcoal (10 to 15 percent) and in other cottage industries, such as brick making, pottery and food. Its share in the aggregated energy consumption was less than 1 percent in 1979.

Garbage has not yet been used as an energy source. Agricultural residue, such as forest and crops, are available as an energy source.

Animal residue has a high potential for biogas energy production. Presently, there are a few thousand biogas digesters. This is expected to increase to about 60,000 within the next decade.

Other crops, such as sugar cane and its molasses, and cassava chips, can be converted to liquid fuel ethanol as well as being used as food and feed stocks.

Aquatic plants, such as water hyacinth and algae, have a high potential as energy sources.

Wind Energy

Wind speed in Thailand, except in some selected areas such as coastal mountainous ranges, is low. Average annual wind speed varies from 7 to 14 kilometers per hour in the west, northeast, north and central sections. Nevertheless, wind energy is of significant importance in water pumping for agriculture. The best locations for development of large-scale wind energy are along the coastal area, especially at Songkhla province in the south and Si Chang island in the east. These have consistent and high wind speed.

Natural Gas

The investigation of the three discovered gas wells in the Gulf of Thailand revealed a reserve of 10 trillion cubic feet. The reserve of liquid natural gas in the three gas wells is estimated at 12,720 billion liters.

Solar Energy

The annual average daily solar radiation in Thailand is about 17 MJ per square meter, which is classified as fairly high, with variation of 15 percent. The climate of Thailand is seasonal, with a rainy period from May to November and a dry season from December to April. Even during the rainy season, long unbroken periods of cloudiness are rare. Rain clouds often build up near afternoon after a bright, sunny morning. Thus, there is usually adequate radiation over most of the country to run solar energy systems effectively.

In spite of moderate publicity by solar equipment distributors, solar energy utilization is not widespread. Solar water heaters using flat plate collectors and auxiliary heaters now are manufactured in Thailand, and they are suitable for commercial purposes such as hotels, factories, hospitals and public services, and for some domestic uses, especially in the northern part.

Oil Shale

The quantity of oil shale in the north of Thailand is still not high enough for commercial production. Because 1 ton of oil shale is estimated to yield an average of 52 liters of oil or about 5 percent of the total weight of oil shale, the expense of extracting oil from oil shale is higher than the price of imported oil. Other possible utilization of oil shale is as a direct fuel for power plants, but again it is not economical. The available information is not enough to determine the trend of the development.

Geothermal

Preliminary investigations indicated that there are at least 65 hot springs distributed across Thailand. Only five promising hot springs, with reservoir temperatures ranging from 175°C to 200°C, have been investigated. The five geothermal systems could offer a possible development for electricity generation, and 11 other hot springs with reservoir temperatures between 100°C and 175°C have been located and could be developed for industrial or agricultural applications.

PLAN FOR NEW AND RENEWABLE ENERGY RESOURCES DEVELOPMENT

The purposes of the plan include:

- To accelerate the indigenous energy resource development as substitutes for imported oil to reduce the share of oil consumption from 75 percent of aggregated energy demand to 45 percent by 1989, and to enable Thailand to lessen its oil dependence on foreign countries.

- To supply energy for rural people in types, quantity and quality appropriate to their needs and living conditions.

- To accelerate the energy resource investigation, need identification, research, development, demonstration, and extension/popularization of energy technologies.

Plan for Development

With highly reliable technologies entrusted in the plan, conventional energy has been developed to substitute for crude oil to a certain extent. Still, it is necessary to set the nonconventional energy development plan apart from the plan for conventional energy because of the differences of their development objectives. The nonconventional energy development objective aims at an accelerated rural development policy.

Major and Mini-Hydro Power Development

Hydro power could substitute for fuel oil and diesel oil in power generation, and electricity might replace kerosene in giving light. The plan calls for the development of large-scale hydro power projects on a normal basis and accelerated development of mini-hydro (having a capacity 100 KW to 6 MW) to five projects yearly for the first three years of the 10-year plan period. For the next seven years, 30 micro-hydro plants are expected to be installed by the government, with more community contribution.

Garbage Energy Development Plan

The plan calls for getting rid of garbage by incineration and making use of the heat to generate the same electricity as that of conventional thermal power plants.

An investment of about U.S. $60 million is required to dispose of 1 million tons of garbage per year and generate energy from 40 MW installed capacity at 250 GWh per year.

Fuel Wood and Charcoal Development Plan

The project subject to this plan is reforestation with the rapid-growth trees on 4.6 million rais (2.5 rais = 1 acre). From 1989, the project is expected to produce about 12.9 million cubic meters per year and natural wood about 9.5 million cubic meters. The investment during the plan period is estimated at U.S. $310 million.

Natural Gas

The program to extract natural gas already has commenced. The construction of the pipeline and other facilities is near completion. It is expected that the gas (225 million liters of crude oil equivalent) will be available in late 1981 and will increase to 6,147 million liters of oil equivalent in 1986.

It is also anticipated that liquid natural gas available in 1982 will amount to 516 million liters of crude oil equivalent.

Biogas Development Plan

The project proposed in the plan is the construction of 106 digesters of community size and 60,000 of household size. The estimated expenditure to be paid by the government is about U.S. $5 million.

Currently, biogas plant design programs consist of development of suitable digesters using cheap material for construction. Three adaptive designs, plus one new model made of cement jars, and design and development of suitable gas holders using non-corrosive materials and drumless digesters are being considered.

Oil Shale Development Plan

Proposed in the plan is a pilot power plant project of 10 to 20 MW capacity using low-quality oil shale. Feasibility studies for an oil extraction project of 50,000 barrels per year using high quality oil shale and for a large power plant are being planned. The pre-investment for the whole plan is about U.S. $30 million.

Ethanol Production Development Plan

The plan to mix ethanol with benzine to use as fuel will start in 1981, after a feasibility study for establishing an alcohol factor is completed. The government share in the plan will be about U.S. $250 million. Should the project prove feasible, there also will be private shares in the investment.

Solar Energy Development Plan

The formulated projects fixed for development and demonstration include such applications of solar energy as solar drying, solar water pumping, solar water distillation and process heat, small-scale solar electricity generation, solar refrigeration and air conditioning.

Wind Energy Development Plan

The plan calls for demonstration of the utilization of wind energy in water pumping for consumption in villages and farming in small areas, including the small-scale electricity generation from wind power for villages in the rural areas where wind velocity is consistent. Several projects will be implemented during this decade, with a proposed budget of U.S. $7 million.

Geothermal Energy Development Plan

This consists of demonstrating the utilization of geothermal energy in drying tobacco leaves and crops to supply farmers with cheap heat, and development of hot springs for electricity generation. Within the scope of work, the preliminary budget is tentatively estimated at U.S. $3 million.

Rural Oriented Energy Technologies Development Plan

The plan includes several components, such as a village energy survey, improvement of cooking stoves, improvement of charcoal production, water gasification and biogasification. It also includes liquid fuel production (ethanol and vegetable oil), solid fuel production (pyrolysis of rice hull, densification of charcoal dust and other fine residue), improvement of furnaces and boilers, water-lifting technologies, village woodlots and establishment of rural energy centers.

To improve the existing use and to supply more energy to rural areas, the budget for implementing these components is estimated at U.S. $18 million.

MAJOR CONSTRAINTS IN IMPLEMENTING THE PLAN

The major and mini-hydro power development plan requires hydrological, topographical, geological, economic and other data for feasibility studies to arrive at an optimum implementation plan. Such data is under intensive investigation and technical support to prepare feasibility studies of the identified projects is requested.

The garbage energy development plan has an institutional constraint. It requires an awareness and understanding by local administrations that garbage can be used not only as raw material for fertilizer production but also as fuel.

The fuel wood and charcoal development plan requires public and government level awarenesss of the fuel wood situation, and that the situation will lead to a rural energy crisis soon. Allocation to the public of deforested plots to establish fast-growing fuel wood plantations and a distribution system are the prerequisites. Government commitment to include such plantations as a top activity in the rural job creation project would facilitate its implementation.

The biogas development plan requires an intensive effort to popularize the techniques and to train selected villagers. Trained villagers paid by the government will introduce the technologies and help select individuals to supervise installation, operation and maintenance of a promotional set in a village. Mass production design to produce cooking gas for a family would help promote biogas utilization.

The oil shale development plan requires standardization of resource evaluation procedures to determine the extent of a deposit. It also requires exploitation technologies to determine potential development methods to best accommodate the resource. This information would enable Thailand to prepare a comprehensive development plan faster.

The ethanol production development plan requires willingness of the private sector to invest. Such willingness is encouraged by government-funded pre-investment studies and favorable loans provided by international financing institutions for procurement of overseas capital and services.

The solar energy development plan requires standardization of ready sets to suit local climatic conditions. Utilization of locally available skill and material in the production process would reduce the high initial cost.

The wind energy development plan requires site-specific investigation and performance standards for wind equipment to be produced locally and introduced to the selected site.

The geothermal energy development plan requires high capital costs needed for the exploration work and production drilling. Provision of the technical service and drilling rigs for the exploration are desirable.

DOCUMENT NUMBERS FOR ORIGINAL U.N. REPORTS

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Volume 1: Mideast and Africa

Egypt, 41	Nigeria, 59
Israel, 19	Pakistan, 1
Jordan, 61	Sierra Leone, 38
Kenya, 36	Sudan, 11
Liberia, 8	Turkey, 63

Volume 2: Far East and the Soviet Union

Australia, 42	Japan, 49
Bangladesh, 68	Soviet Union, 51
China, 23	Sri Lanka, 76
Indonesia, 52	Thailand, 65

Volume 3: Western Europe and North America

Austria, 74	Italy, 37
Canada, 62	Netherlands, 15
Denmark, 34	Norway, 18
France, 7	Sweden, 21
Ireland, 28	United States, 40
	West Germany, 27

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