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# BANGLADESH**

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# THE NATIONAL PAPER

OF THE

## GOVERNMENT OF THE PEOPLE'S REPUBLIC OF BANGLADESH

*PRESENTED TO THE*

# UNITED NATIONS' CONFERENCE

ON

# NEW AND RENEWABLE SOURCES OF ENERGY

*TO BE HELD*

IN

**NAIROBI–KENYA**

**AUGUST 1981**

# NEW AND RENEWABLE SOURCES OF ENERGY IN BANGLADESH

## TABLE OF CONTENTS

## The Country

Spanning a territory from the lower Himalayan region to the Bay of Bengal, Bangladesh is a flat deltaic region washed by some of the mightiest rivers of the world. The total surface area is about 55,598 sq. miles (143,998 sq. km) 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 0·38 acre while the cultivable land per head is even less than 0·27 acre. The urban population hardly being 10% of the total population, Bangladesh is like a big continuous village. There are mainly three distinct seasons, Winter (Nov.—Feb.), Summer (March—June) and Monsoon (July—October). Average winter temperature varies from 84°F (Maximum) and 52·1°F (Minimum) and the Summer temperature is between 94·1°F (Maximum) and 69·6°F (Minimum). Average rainfall in the country varies, being less in the north-western region, but 100 inches may be assumed as average for the country. Average sun shine 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.

## Economy

Bangladesh is basically a country of traditional agriculture, following age old methods and using little commercial energy. The economy derives about 54% of its GDP from agriculture, other components being about 12·3% due to large and small industries, 10·8% trade, around 6% each to transport and communication, housing and other services, 2·46% to public administration and 1% to banking and insurance.

Although more than half of the GDP is attributable to agriculture, only 12% 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.

## Energy Situation

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

Virtually all petroleum and petroleum products and coal are imported but natural gas is indigenous. Expressed in coal equivalent term, the total use of commercial energy in Bangladesh was nearly 4 million tons of coal equivalent in 1979-80. Of this, the contribution of oil and oil products was 53%, gas 37% while coal and hydro-electricity was about 5% each.

Bangladesh uses around 1·6 million tons of petroleum and petroleum products per year, all of which is imported, and though the trend is towards increase, the Government is taking steps to contain the same. 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 middistillate requirement including kerosene and diesel has to be imported as finished products. The cost of import of oil is heavily affecting the balance of payment of the country, as in gross terms, it is claiming nearly two-thirds of the total export earnings. However, some surplus products after refining is also exported which eases the situation slightly. Use of natural gas saves around 220 million dollars equivalent of foreign exchange at the current level of consumption and though there is plenty of gas resource, constraints are hindering its fast enough use to replace oil.

**Commercial Energy Resource**

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 TCF. Final reserve may be much larger as for a country of about 56,000 sq. miles, only about sixty wells have been drilled so far. However the proven gas reserve though small according to international standards is ample for the country's needs for quite sometime. 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 1000—1500 million 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, hydropotential of the country is very limited. Present estimate puts the resource as 1300 MW of which only 130 MW has been harnessed so far. However the prospects of significant increase of hydropotential exploitation are limited due to many reasons.

**New and Renewable Sources of Energy**

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 cowdung, rice husks, crop residues, vegetable wastes, firewood and the like. Being situated in hot humid region, and the landmass being criss-crossed by innumerable rivers and streams, the region is ideal for fast growth of biomass.

Considering her topography, geographical location, climatic condition and resource endowments, the following sources have been considered for Bangladesh:

(i) Solar
(ii) Biomass
(iii) Peat
(iv) Wind
(v) Minihydro
(vi) Geothermal
(vii) Ocean

**Solar Energy**

Owing to the location in the tropics between the latitude of 20·34° and 26·38° North, 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 are very common. Theoretical estimate of the total radiation falling on Bangladesh has been placed around $700—900\times10^{15}$ KJ/ year. A fraction of a per cent 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 process.

In the thermal process, application of solar energy can be made for improvement of traditional drying process of fish, crops, grains etc., and also for running of refrigerator of high thermal efficiency in the rural areas, some low temperature heat system for industries etc. Solar thermal power system

has potential in water pump for irrigation and also for motive power for rural small industries. Solar photovoltaic has potential use in operating radio, television, freeze, lighting etc. 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 of using solar energy in the following fields:—

*Direct Thermal Application*

(i) Drying.
(ii) Hot water for domestic and industrial use.
(iii) Solar cooling and refrigeration.
(iv) Desalination of water and brackish water.
(v) Domestic Cooking.

*Solar Cells*

(i) Radio, Television.
(ii) Refrigerator.
(iii) 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, spices, etc. The dryer proved successful in killing fly larvae and adult flies. An improvement of drying time of 25 per cent is possible. Hot boxes and cabinet type dryers are also being developed to dry paddy and chillies during the monsoon.

**Solar Stills**

Basin type solar distillation stills with 3·5 per cent 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 have also 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

agrobased industries in rural areas where at present power on a small scale is usually supplied by diesel engines. Besides this, the development of a simple pump to be operated by high pressure vapours of low boiling point organic liquids obtained from flat plate collectors without involving the use of 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 has also been taken in hand.

**Solar Salt Production**

Evaporation of sea water by solar energy is the only method of salt production in Bangladesh. In order 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 ammonia-water system was operated with solar heating provided by a parabolic reflector having 1·4 m. diameter and 0·27 kg. of ice could be produced per 0·45 kg. of refrigerant by an hour of solar heating. Some work on absorption refrigeration system with various refrigerant absorbent combinations has also been initiated to study the factors affecting the coefficient of performance. After the successful completion of the investigation, a pilot plant of abount 90 kg/day capacity solar ice making machine is planned to be set up.

**Solar Cooker**

In theory, solar cookers can supply as much as 50% of the cooking energy need of the country, but the well known problems in acceptability of solar cookers in real life originating from 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 its research and propagation and a cooker employing parabolic reflector with frontial area of 1 $m^2$ and focal length of 0·46 m has been constructed. It is claimed that it can cook rice for a

family of 5-6 members in 20—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 collector having two covers and hot boxes with provision for heat storage are also 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 from the view points of materials and trained technicians. These and other aspects like storage, etc., must be given active considerations. Paddy pre-heating before parboiling, textiles, sericulture, hospitals, rural health centres, restaurants, hotels, etc., 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 sizeable impact of solar power may have on the national economy, particularly in the rural sector, the following steps are being taken for its development:

(i) Fabrication of silicon cells using diffusion technique.
(ii) Development of cadmium sulphide and copper sulphide cells.
(iii) Fabrication of silicon wafers.
(iv) Study on electricity generation by solar cell panels under the local climatic conditions and development of storage batteries and other end use equipment like alternators, dc motors, etc.

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

**Solar Data**

Comprehensive solar radiation data are not available for the country causing problems for study and research in solar energy. There are forty-two meterological stations located in the country which have to be equipped with instruments for recording solar radiation incidences, documenting the data and disseminating the same.

**Constraints and suggestions for their removal**

It seems that, in broad economic and technological terms, general world-wide application of new and renewable energy technologies is now practical. The potential for the development and use of these technologies at the desired level exists in developing countries as well. However, there are a number of constraints which must be tackled effectively through appropriate and urgent action. This also applies to the traditional forms of renewable energy which require recognition, reappraisal and technological input if they are to fulfill their potential in a much more effective and meaningful way.

There is a need of enunciating policies for long-medium and short-term development and use of new and renewable sources of energy as a whole. Emphasis should be given on the social and economic development of the rural areas and the significant contribution made at present by the traditional renewable sources in the rural sector. There is a need for national institutional structures that contain focal points at appropriate levels of the Government to promote the development and use of new and renewable sources of energy within the framework of national development activities.

Most of the world's research and development activities in the field of new and renewable energy are concentrated in industrialized countries resulting in the design of technological system primarily applicable to the developed countries. If developing countries are to benefit from this work through the adoption of techniques and systems that meet their specific needs, ways for their active participation in current scientific and technological efforts must be ensured through effective collaboration between developed and developing countries. Past experience had shown that technology transfer often leads to long-term technological dependence. This should be avoided by giving attention to the development of energy technologies adapted to the specific condition of development countries. Industrialized countries should also help the developing countries to strengthen their technological research and development capacity. All information including proprietory information from all possible sources must be made generally available. Along with energy technology development, due attention should also be given to the development, of suitable end-use equipment for maximum possible social and economic impact.

There is a tremendous shortage of trained personnel and lack of awareness among the people. It is necessary to develop and adopt training programmes, facilities and materials at the university, secondary and primary

levels, as well as in the training of technicians. Widespread awareness among the end-users should be created by the use of many forms of communication, from demonstration of projects to the mass media.

Financial constraints pose the most serious barrier for research and development of new and renewable energy technologies in Bangladesh. These have to be removed through national and international efforts if the vast majority of the people living in the poor rural areas are to benefit from the world-wide activities on new and renewable energy sources. The quality of life of the rural people must be improved, otherwise the so-called development will not mean anything for the majority of the population. International agencies have also to play a vital role in this regard. To take care of immediate financial needs, an international interim fund should be created to support the research and development activities of developing countries.

**Biogas**

As biogas is a kind of fuel gas obtained from aneoreberic decomposition of animal and agricultural waste and as the technology is claimed to be simple, it is believed to be of considerable economic importance specially 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 over 0·5 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 as 100% 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 cowdung per cattle is believed to be far smaller than the average of 20 lbs. used in theoretical calculation in published literature. From the point of view of socio-economic structure, life style, average family size, land holding, income per year, animal per family and the culture of animal keeping practices and the work done out of cattle, initial investment for infrastructure, and the multipurpose use of cowdung from masonry to manure, and the need to see biogas as an integrated system including processing of end product of sludge and effluent from environmental consideration, it is unlikely that a major portion of the cowdung will be collected for

biogas production. A rough calculation shows that the theoretical maximum possibility of biogas, taking the maximum per capita production of dung of 20 lbs./cattle and all dungs as collected and digested for biogas, will give between $9 \cdot 1 \times 10^{12}$ to $15 \cdot 9 \times 10^{12}$ KCal per year assuming 0·8—1·4 cft/Kg of dung. Taking the equivalent heat, the said maximum potential of biogas would be equivalent to one 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. Experience will only show what is actually feasible in practice.

**Present Status and Activities**

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 like the Institute of Fuel Research and Development under the Bangladesh Council for scientific and Industrial Research (BCSIR), 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 grownup cows can generate biogas, enough for daily cooking of a family of 6-7 members. A family size plant (100 cft. capacity) with floating top gas collector using brick, cement and mild steel sheet as construction material costs about US $ 675·00. The same plant with fixed top gas collector using brick and cement costs about US $ 400·00. The operation of the former is, however, simpler than the latter. Plants with floating top and fixed top gas collectors are now in operation in different parts of the country.

**R & D Programme**

The Institute of Fuel Research and Development under the BCSIR is now 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 also undertaken programmes 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 Non-Government agencies are getting increasingly involved in the dissemination of biogas technology.

Current research activities in the Institute of Fuel Research and Development of BCSIR, Engineering University, Agricultural University and Environment Pollution Control Department are directed towards the following:

(a) Since this technology is meant for decentralized rural application, cost is probably the most dominant factor controlling its wide application. The present cost of over US $ 400·00 for a family size plant is too high for an average rural family in Bangladesh. Further R & D work aimed at lowering the cost utilizing local construction materials is needed.

(b) At present droppings from 4-5 cows are needed for getting enough gas for daily cooking and lighting of a family of 6-7 members. This is because, at the ambient temperature, only 15 to 30% of the carbon available in cow-dung are 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. Special strain of bacteria is capable of giving higher conversion. Further R & D activities in this line will lower the construction cost by reducing the size of the plant and also reduce loading rate without decreasing the plant capacity.

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

(d) 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 family, utilization of other raw materials has become necessary. Water hyacinth may very well fill up this gap. But some kind of preprocessing is required before it can be mixed with cow-dung while charging the biogas plant.

(e) 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.

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

(g) The storage of biogas is another problem. Further work aimed at development of better storage system is needed.

**Constraints :**

(a) Socio-cultural living system

(b) Hisgh construction cost

(c) Uncertainty in technology

(d) Lack of Public awareness

(e) Dearth of trained man-power

**Recommendation**

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

(b) Since wide-spread use of this technology will reduce pressure on conventional fuels, an international fund may be made available for financing the R & D Programme for sharing of failures and success of the experience of biogas.

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

(d) Institutions engaged in R & D activities on biogas should be strengthened in respect of fund, facilities and manpower.

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

**Biomass (Fuel wood)**

In Bangladesh Government forest covers about 9% of the total land surface. Deforestation reaching alarming proportion has been going on for the following reasons:—

(i) Increase in the population.

(ii) Indiscriminate felling of trees for industries and construction of houses.

(iii) Claiming of land for agricultural purposes.

(iv) Shifting cultivation by some tribal people.

(v) Fuel wood collection for cooking and burning of bricks.

(vi) High prices of timber and fuel.

Being situated in the tropical fertile land, prospects of biomass production is high if proper planning and management are done in the development of biomass resource of the country. 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 embankment, railway line, canal banks, firm land ridge, compounds of homestead, educational institutes, space in mills and factories for the purpose.

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

| | | |
|---|---|---|
| (1) Slopes of roads and highways | .. | 2,885 miles. |
| (2) Roads maintained by local Government institutions. | .. | 87,000 miles. |
| (3) Railway | .. | 1,786 miles. |
| (4) Banks of Tanks | .. | 22,00,000 Nos. |
| (5) Compounds of mosques | .. | over 2 lakhs. |
| (6) Farm land ridges | .. | nearly 2,000 sq. miles |
| (7) Compounds of factories and Educational institutions. | .. | |

Ideal energy farming will be an optimum balance of the product in terms of food, fodder, timber and at the same time raw material for cottage industries. Giant 1pil 1pil, Korai, Australian Accasia, Eucalyptus, etc., 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 is as follows:—

| | | | |
|---|---|---|---|
| Moisture | .. | .. | 6·48% |
| Ash contents | .. | .. | 32·96% |
| Volatile matter | .. | .. | 45·04% |
| Fixed Carbon | .. | .. | 15·52% |
| Calorific value | .. | .. | 5905BTU/lb. |

Briquette tests as well as 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 potential of wind energy. However areas near the shore line of the Bay of Bengal has higher wind velocity than the inland area of the country. Analysis of data near Chittagong Airport area, which is near the coast line, has a wind speed of about 4 m/s or higher for 3000 hours in a year whereas 6 m/s is available for 1650 hours per year. The most probable wind speed is 1.6 m/s. The maximum hourly mean wind speed over the year is 5·7 m/s, occurring at 14th hour of the day whereas the minimum is about 2·6 m/s at 02nd hour. The yearly average wind speed is found to be 3.2 m/s. Among the locations measured for wind speed, Teknaf in the southern tip of the coast line has shown highest wind velocity.

As 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 R & D 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:

(i) Wind data as recorded by meteorological stations are being analysed in details. Some inaccuracies, defects and limitations in recording the data have been detected.

(ii) Small vertical axis wind turbine like 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 m/s with a maximum overall efficiency of about 10%. 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.

(iii) A vertical blade Darrieus having a height of 4 m and diameter of 5 m with NACA 0015 airfoil (chord-0·97 m) has been designed and is under consideration by using 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.

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

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

**Recommendations for future R & D Programme**

As wind energy in complement of other sources, may contribute reasonably towards the energy needs of rural Bangladesh, active consideration must be given to the following:

(i) Wind data at many more locations other than the meteorological stations should be recorded accurately on standard format and analysed. Arrangements should be made for proper documentation and dissemination of the information among the people and organisations involved.

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

(iii) Electric power generation by wind energy for isolated villages in the coastal areas and off-shore islands may be considered. At present, the power requirement for such a village is estimated to be between 15—20 kw. Proven wind turbines, generators and storage facilities may be selected as pilot project before large scale use of them can be recommended.

(iv) Performance study of the conventional sails used for the propulsion boats should be made and recommendations may be put forward for possible improvements in the traditional use of wind energy.

**Small Hydro Project**

Total hydro potential of the country is limited as the country is a flat basin and the northern part declines from a height of only 85 m to sea level in the southern parts over a distance of 400 km, giving a slope of 1 in 4700. Thus although there is a run off of about 100 million acre-ft. of water over an area of about 36 million acres, there has been no major source of hydro electricity, and as mentioned earlier, the total potential has been estimated as only 1300 MW. No serious consideration was given about the potential of small hydroprojects in Bangladesh. It is only recently that Bangladesh Water Development Board and Power Development Board together conducted a Reconnaissance Survey in four small areas to identify minihydro sites on a number of streams. Preliminary report of this survey is reported to be encouraging. Multipurpose irrigation projects are being given consideration for the generation of hydropower. In an irrigation barrage in the Northern Bangladesh, it is assumed that with an average flow of 170 cusec and at an assumed head of 3·65 m 45 GWh can be generated at the proposed barrage. For harnessing this energy, axial flow bulb type turbines have been recommended. Similar potentials have also been identified at another barrage with a possibility of harnessing 179 GWh, employing fifteen 2·5 MW axial flow bulb turbine. 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 period of time.

**Research and Development Needs**

(a) A comprehensive survey of the country for small and mini hydro may be undertaken to know the potential of this energy source.

(b) International, regional and bilateral cooperation will be helpful for the sharing of experience in this field.

**Geothermal Source**

At present there is no known geothermal source in Bangladesh. However, structural geology of Bangladesh indicates certain places 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 of that area, providing an opportunity for producing geothermal energy.

Structural geology of the folded region of Chittagong and Chittagong Hill Tracts are also prospective zones especially where the hot spring of Sitakund already exists.

The preliminary borehole information suggests that the strata temperature at or about 3000 ft. below in the southern slope of Rangpur saddle is about 125°F. But no exploratory hole has been made in connection with harnessing of 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 from geothermal energy point of view.

No effort has so far been taken on the investigation of geothermal source in the country. Expertise in the field is also scarce. Information pooling on a regional basis will be of much benefit to Bangladesh. Expert services in the field will also be helpful in taking action programme for survey and investigation of this source.

**Ocean Energy**

Awareness that ocean energy may be of some value in Bangladesh is of recent origin. 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 thorough comprehensive study covering all aspects of data covering ocean thermal gradients, tides, waves, currents and salinity gradients would be a proper thing to do 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 got pronounced effect on the high and low waters of these estuaries. Tide range in general varies between 3—6 m.

No reliable estimates about the potential energy resource from ocean energy is available.

**Alternative Energy and Renewable Sources**

It has been stated that roughly about one-third of the total estimated energy needs of the country is supplied by commercial fuels, of which about 50 per cent is imported petroleum and petroleum products. Of the petroleum

products needs nearly 50% being diesel, it has a direct bearing on the rural economy in meeting the fuel needs for irrigation pumping and transportation. Another 30% 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 only meant gradual denial of basic supplies of energy to rural people affecting both their economic activities and the standard of living.

Of the traditional energy sources, accounting for two-thirds of the total energy needs, nearly all consumers being rural, the main supplies have been cow-dung, rice straws and husks accounting for an estimated two-thirds of the total traditional energy, the remaining one-third being in the form of fire-wood, leaves, twigs, baggasses and other agricultural wastes. Thus bio-mass have all along played a major role in the energy balance of the country touching directly as well as indirectly the life and living of 90 per cent of the population of the country. But the low and gradually dwindling land-man ratio and the increasing landlessness for a large cross section of the populace have been posing a problem in development and utilization of bio-mass energy also. Fire-wood being the most important source of fuel for cooking and heating, excessive deforestation without taking care for adequate regeneration has, on the one hand, started serious environmental degradation and began the process of dessertification, and on the other, scarcity has shot up the price of fire-wood 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 fire-wood which was selling at Tk. 26 per maund (82·3 lbs) 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 fire-wood, it has become in real terms more expensive than the imported kerosene.

The crunch of the high price of imported fuel as well as 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 necesssary, 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 for some forms of renewable energy with bright prospects like solar photovoltaic

or bio-gas, massive programmes for short cycle tree plantation, preferably for multipurpose use such as fuel and fodder brook no further delay. However in all the possible programmes for development and use of new and renewable sources of energy, the need for collaboration with an assistance of others on technology, methods, access to research results, and above all finances stands out as paramount.

**Cooperation: Bilateral, Regional and International:**

Bangladesh has basically a rural economy and largely dependent on traditional renewable sources of energy. But these are decreasing in absolute terms because of the high population growth. Bangladesh will, therefore, be benefitted most by exploiting the technology of harnessing new and renewable sources of energy particularly Solar, Bio-mass and Wind. The problem of new and renewable energy development and extension in different countries have many common aspects. A very substantial saving of time, manpower and money can be achieved through international co-operation in both R & D efforts as well as real transfer of technology.

Specific proposals which Bangladesh would like the conference to consider are:

(i) Creation of a specialized international organisation to help developing countries in,

(a) assessment and development of indigenous energy resources.

(b) research, development and extension of new and renewable energy including building up of proper institutions for the same.

(c) transfer of technology and practices in renewable energy fields.

(d) training of personnel for improving skills in research, development, manufacture and extension of new and renewable energy technologies.

(ii) Creation of a special fund for helping developing countries in,

(a) research, development, transfer of technology, training of manpower and manufacture on new and renewable energy fields.

(b) organization of demonstration projects designed both to test application and to disseminate information on technologies related to new and renewable sources of energy.

(c) formation of design and information bank for helping developing countries with the design of both new and proven technologies in the field of renewable energy sources.

(d) organizing of seminars and conferences to stimulate research and development of new and renewable energy fields.

(e) publication of regional and global energy survey, with particular emphasis on new and renewable sources of energy, covering both supply and consumption figures.

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