

1. Introduction

Bangladesh is one of the most densely populated countries with 79% of the population living in rural areas. The primarily agricultural economy of Bangladesh has recorded around 5% annual growth rate over the last few years (ADB, 2001). The main crops grown in the country are rice and jute. The main energy sources of Bangladesh are biomass and natural gas. Biomass energy sources are traditionally used for domestic cooking and in small rural industries. Biomass fuels are estimated to account for about 73% of the country's primary energy supply (World Bank, 1998). The country's per capita annual energy consumption in 1997 was about 77 kgoe, and it was much below the world average of 1474 kgoe (ADB, 2001). Only around 30% of the population has access to electricity (BPDB, 2002). Over 80% of people depend on traditional energy sources such as firewood, cow dung and agricultural residues for their energy needs. Excessive use of firewoods threatens the remaining forest cover, which is only 10% of the total land area (WEC, 2000).

Bangladesh is endowed with vast renewable energy resources such as solar insolation and biomass. Harnessing these resources appears to be a promising solution for improving the quality of life of rural villagers, who are unlikely to have access to conventional electricity supply in the foreseeable future.

This paper describes the status of the Renewable Energy Technologies (RETs) in Bangladesh in terms of its policy issues, implementation, dissemination, marketing, research and development activities. Modern RETs are still in the research, development and demonstration phase in the country. Like most of the developing countries, there is a niche market for new RETs and several private sector entrepreneurs and NGOs have tried to explore this market which is the prime focus of this paper.

Keywords : *Solar energy, wind energy, biomass, tidal*

2. Institutional Framework

There is no national coordinating agency for Renewable Energy sector in Bangladesh. At present, Powercell is entrusted by the Ministry of Energy and Mineral Resources (MEMR) to foster development of RETs in Bangladesh.

Status of Renewable Energy Technologies in Bangladesh

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The utilities responsible for generation of electricity are – (1) Bangladesh Power Development Board (BPDB), which is the largest authority to generate electricity from the conventional sources (like indigenous gas, hydro, diesel, furnace oil) and (2) Rural Electrification Board (REB), distributing electricity in the rural areas and generating electricity through Independent Power

Producers (IPPs). Distribution of electricity to the consumer end is performed by - BPDB, Dhaka Electric Supply Authority (DESA), Dhaka Electric Supply Company Ltd. (DESCO) and REB. Several government organization (BPDB, LGED, REB, IFRD), academic institutions (BUET, DU, CUET, RUET, KUET), non-government organizations (Grameen Shakti, BRAC) and private companies are involved in renewable energy sector in the country. Establishment of Renewable Energy Development Agency (REDA) has been proposed by the National Energy Policy (NEP), 1995 of GOB.

3. Policy Support

“National Energy Policy (NEP), 1995” of Bangladesh has got guidelines for Renewable Energy Technologies. Government has also adopted “Private Power Generation Policy, 1996” for encouraging private sector participation in the electricity generation sector of the country along with BPDB and already several Independent Power Producers (IPPs) are supplying electricity to the national grid. Apart from this, another policy – “Small Power Generation Policy, 1998” has also been introduced to encourage small electricity generation capacity up to 10 MW throughout the country by the private sector. A “Draft Renewable Energy Policy” has been submitted by the Power Cell of MEMR which is yet to be approved by the Government of Bangladesh (GOB).

4. Incentives in the Ret Sector

In 1998, The Government of Bangladesh (GOB) lifted import duty and Value Added Tax (VAT) from solar photovoltaic and wind turbines. Solar PV program of different government bodies (BPDB, LGED, REB) are basically subsidy driven. At present, under the Biogas Pilot Plant project, the Government of Bangladesh (GOB) gives 7,500 Taka subsidy for a family-size biogas plant which can be used for cooking and lighting purposes.

5. Prospects of Ret Applications in Bangladesh

Biogas Plants

An agriculture based country like Bangladesh has huge potentials for utilizing biogas technologies. According to an estimate "29.7 billion m₃ of biogas can be obtained from the livestock of the country which is equivalent to 1.5 million tons of kerosene (which is the principal fuel in the rural areas). Apart from this, it is also possible to get biogas from human excreta, poultry dropping, waste, marine plants etc. If each family of Bangladesh can be associated with a biogas plant, then only human excreta will give about 10 billion cubic m₃ biogas". According to IFRD - there is potential of about four million biogas plants in our country.

Solar Photovoltaic

Bangladesh receives an average daily solar radiation of 4 – 6.5 kWh/m². Despite large potential, utilization of solar energy has been limited to traditional uses such as crop and fish drying in the open sun. Solar photovoltaic (PV) are gaining acceptance for providing electricity to households and small businesses in rural areas. In 1988, Bangladesh Atomic Energy Commission (BAEC) installed several pilot PV systems. The first significant PV-based rural electrification programme was the Norshingdi project initiated with financial support from France. Three Battery charging stations with a total capacity of 29.4 kWp and a number of stand alone solar home systems (SHS) with a total capacity of 32.586 kWp were installed. Rural electrification Board (REB) owned the systems and the users paid a monthly fee for the services. Since 1996, penetration of SHSs increased rapidly, mainly due to the efforts of Grameen Shakti, which sells PV systems on credit to rural households through its extensive network. Several other NGOs such as CMES and BRAC are also engaged in promoting PV technology. PV modules are generally imported, while there are a few private companies manufacturing PV accessories (Shakti, 2002).

According to a World Bank funded market survey, there is an existing market size of 0.5 million households for Solar Home Systems (SHS) on a fee-for-service basis in the off-grid areas of Bangladesh. This assessment is based on current expenditure levels on fuel for lighting and battery charging being substituted by SHS [World Bank, 1998]. Also it has been observed that in most developing countries, households typically spend not more than 5% of their income on lighting and use of small appliances. By this measure, about 4.8 million rural Bangladeshi households could pay for a solar home system [World Bank, 1998].

At present the national grid is serving only 50% of the nearly 10,000 rural markets and commercial centres in the country which are excellent market for centralized solar photovoltaic plants. Currently private diesel genset operators are serving in most of the off-grid rural markets and it has been found that 82% of them are also interested in marketing SHS in surrounding areas if some sorts of favorable financing arrangements are available [World Bank, 2000].

Throughout the country, different government administrative offices, NGO offices, Health Centres, Schools, banks, police stations etc are functioning. In the off-grid locations, these offices are either using traditional means (lantern, candles, kerosene wick lamps etc.) or operating their own diesel gensets. These offices have separate budgets for elec-

tricity and they can be easily served with solar photovoltaic applications.

Wind, Small Hydro, Tidal and Others

Market Survey for wind, small-hydro, modern biomass or other types of RET applications are not yet been done properly. From the previous resource potentials it can be implied that

- ✓ Small Wind Turbines can be installed in the coastal region and off-shore islands of the country.
- ✓ Micro Hydro power plants can be installed in the north-eastern hilly regions and in the existing irrigational canal system with sufficient head.
- ✓ There are scopes of integrated tidal power plants in the coastal regions.

6. Financing Mechanisms

Biogas Plants

At present under the Biogas Pilot Plant project, the Government of Bangladesh (GOB) gives 7,500 Taka subsidy for a family-size biogas plant which can be used for cooking and lighting.

Solar Home Systems (SHS)

Currently different financing mechanisms are available for Solar Home Systems. Mainly there are three types :

1. The fee-for-service option (implemented by REB Narsingdi 62kW Solar Photovoltaic Project and will be replicated in other off-grid areas in the future projects)
2. Credit Sell option (implemented by Grameen Shakti, LGED, BPDB)
3. Cash Sell (implemented by Grameen Shakti and different dealers)

Fee-for-Service Scheme

About 800 Solar Photovoltaic units of five systems ranging from 6 to 92 Wp have been supplied or installed in the 62kW Solar Photovoltaic Project at Narsingdi. Consumers pay monthly bills according to the acquired system. All the new SHS projects of REB will follow the fee-for-service scheme in the future.

LGED and CMES has also tried to investigate the fee-for-service option in remote market places and found satisfactory results.

Credit Program of Grameen Shakti

GS offer the following four credit modes for those who want to buy the system on credit.

Mode-1:

1. The customer has to pay 15% of the total price as down payment.
2. The remaining 85% of the cost are to be repaid within 36 months with 12% service charge.

Mode-2:

1. The customer has to pay 25% of the total price as down payment.
2. The remaining 75% of the cost are to be repaid within 24 months with 8% service charge.

Mode-3:

1. The customer has to pay 15% of the total price as down payment.
2. The remaining 85% of the loan amount including 10% service charges are to be repaid by 36 account payee cheques in advance.

Mode-4:

4% discount is allowed on listed price in case of cash purchase.

Subsidized Credit Sell

LGED has implemented a Credit Sell Scheme for solar home systems with subsidy under the Sustainable Rural Energy (SRE) program. BPDB is currently implementing subsidized credit sell of different solar PV applications in the Chittagong Hill Tracts Solar Electrification Project

6. Dissemination & Awareness Program

At present several organizations (including IDCOL, REB, Grameen Shakti, RERC, CMES) are implementing RETs related dissemination and awareness programme.

Major Activities for RET dissemination and awareness program in the country are -

- i. Publicity through Electronic Media: Production and tele-cast of short duration video films/spots/serials through TV channels.
- ii. Publicity through Print & Postal Media: Publication of brochures/folders/booklets/news letters/trade guide/calendar on RETs.
- iii. Publicity through Exhibitions and Outdoor Media: Organizing publicity campaigns/mobile exhibitions in rural/remote and far-flung areas through Mobile Exhibition Vans.

7. Research and Development Activities

The different institutes, universities and research organizations (both public and private) are carrying out research and development (R&D) activities in various fields of renewable energy technologies. R&D activities of Bangladesh are characterized by many constraints, including the lack of expert knowledge and financial resources. Different organizations and their field of interest related to R&D of RETs are presented in Table 1.

Table 1: Status of R&D Activities of Different Organizations

Technology	Related Organization	Remarks
Solar Photovoltaic balance of systems	Garmeen Shakti CMES IFRD	Local manufacturing of all balance of system components (like Charge Controller, Cable, Inverter, Converter etc.) possible
Solar Water Heaters	RERC, Dhaka University IFRD CMES	Manufacturing with local design and fabrication facility possible.
Improved Stoves	IFRD	Several designs have been developed at IFRD in three basic categories : Without chimney, with chimney, and with waste heat utilization.
Solar Cooker - Parabolic	IFRD ANANDO	IFRD has successfully field-tested its design which can quickly boil water on clear sunny days. Such solar cookers are now on sale at a cost of Tk. 450.00 (US\$ 9.00) at IFRD. ANANDO is also manufacturing and marketing it's products with imported materials and design.
Solar Cooker – Box Type	IFRD CMES	IFRD's design is made of locally available raw materials. The manufacturing costs of such a cooker is about Tk. 800 (US\$ 16.00) excluding the cost of utensils. The cookers are now being sold at IFRD.
Solar Dryer	IFRD BRRI BAU	Different types have been designed and tested with locally available materials.
Solar Wood Seasoning Plant	BFRI	A simple, inexpensive and effective solar kiln has been developed for seasoning timber using solar radiation. The kiln can be constructed conveniently with locally available materials. Timbers of different species and dimensions can be seasoned throughout the year in the solar kiln.
Solar Passive Architecture	BCSIR	A solar house has been designed and built in the BCSIR campus, the purpose is to keep the house warm in winter and cool in summer.
Briquetting Machine	KUET, Khulna BRRI	Under the "RET in Asia" program, BIT Chittagong is developing better machines with longer screw life.
Biogas	IFRD LGED BAU	Fixed-dome type plants are found to be more suitable for local conditions and disseminated with government subsidy of Taka 5000.
Wind Pumps	LGED	LGED has designed and manufactured low cost wind pumps with a rated capacity of 20,000 litres of water per day at 4.0 m/s wind speed. Six such prototypes are already installed at different parts of the country.
Wind Turbines	BUET	Computational models are developed for the simulation of horizontal and vertical axis wind turbines.

8. Notable Initiatives

A summary of the current

Several attempts for overall development of the Renewable Energy sector have been taken up by some of the government organizations and NGOs which are described in the following paragraphs.

Table 2 : Summary of New RETs in Bangladesh

Technology	Installed Capacity (approximate estimation)
Solar Photovoltaic	800 kWp / 15,000 SHS
Wind Turbine	20 kW
Wind Pump	6 nos.
Biogas Plants	10,000 nos.
Micro Hydro	10 kW

Projects by Government Organizations

Biogas Pilot Plant Project of IFRD

This project has been implemented by the Institute of Fuel Research and Development (IFRD) since 1995. Under the project up to June 2000, 4664 biogas plants were constructed. According to an assessment report it has been seen that 99% of the plants installed under the project are in operation and 91% of the owners could met their household fuel demand from the plants. The project helped retain organic fertilizer in the soil, enhanced agricultural production, ensured pollution-free environment, provided alternative sources of energy in the rural areas and helped developing human resources.

Under the Second Phase of the project 20,000 biogas plants will be installed throughout the country within June, 2004. These plants will act as demonstration plants. To materialize the project in the field level, along with 128 Sub-Assistant Biogas Engineers, approximately 50 Agencies will be employed. They will be assigned with responsibilities for motivation, installation, troubleshooting, follow-up, monitoring and back-up services concerning biogas technology. 250 participants from Government bodies, NGOs, untrained manpower of the project and unemployed local youths (with science background), who can support the programme in the field level will be given 10 days intensive training (theoretical and practical) on biogas technology. 1000 local masons, on an average two from each upazila (sub-district), will also be trained on leak-proof biogas plant construction technique for seven days to make available technical manpower at the doorsteps of the entrepreneurs.

Biogas Project of LGED

LGED is also implementing Biogas Project for wide-scale dissemination of the technology. LGED has already installed about 1,000 Biogas Plant of different types from diversified substrates including cowdung, hyacinth, human excreta.

Chittagong Hill Tracts Solar Electrification Project of BPDB

Engineers of BPDB have conducted a "Feasibility Study for Solar PV in Chittagong Hill Tracts Region" and currently implementing Solar Photovoltaic Project at three upazilas in the Chittagong Hill Tracts region where different types of solar photovoltaic applications including solar home systems, water pumps, vaccine refrigerators, street lamps, centralize power station etc. will be installed very soon. The overall charge of supervision and bill collection of different systems will be done by the Beneficiary Management Committee composed by the local people.

Wind Resource Assessment Program (WRAP) of BPDB

According to preliminary study conducted by BPDB, Muhuri Dam area at Feni has got bright prospects of electricity generation from wind. Reliable and long term wind data (at least one year) will enable BPDB to determine the exact wind speed of higher heights and wind energy yield from the site from a suitable wind turbine. In this backdrop BPDB has decided to undertake the Wind Resource Assessment Program (WRAP) at the Muhuri Dam site at 50 meter height for one year. BPDB has appointed a consultant to carry-out the task.

The broad objectives of the project are:

- ✓ To prepare the recommendations for the implementation of main project.
- ✓ To record systematically 1 years wind resource data with automated data logging equipment near the Muhuri Dam area
- ✓ To determine the roughness index and orography of the site
- ✓ To determine the standard Weibull characteristics (Shape and Scale parameter) for the site
- ✓ To compare various wind speed characteristics with other sources (e.g. satellite wind mapping data).
- ✓ To select suitable Wind-Driven Systems (either grid-interactive or hybrid power plant) based on the above information.

Micro Hydro Power Plant at Barkal by BPDB

Barkal is one of the remote and unelectrified Upazila (sub-district) in the Chittagong Hill Tracts region. The area is covered with hills ranging 300 to 500 meters in height. Due to the geological structure, the area is remote in terms of building the infrastructure. Therefore, the extension of grid electricity will be very difficult and expensive. Engineers of BPDB have conducted reconnaissance survey in the Upazila and identified availability of water sources for Micro Hydro Power Plant. Based on the electrical load demand of the adjacent area of the proposed 20 kW Micro Hydro Power Plant is designed with the help of RETScreen, developed by CAN-MET Energy Diversification Research Laboratory of Canada (CEDRL).

The project will be funded by the Ministry of Chittagong Hill Tracts Affairs.

“Diffusion of Renewable Energy Technologies” Project by REB

Under the first phase of the project, a “Renewable Energy” cell of Rural Electrification Board (REB) has implemented the first semi-commercial 62 kW Solar Photovoltaic Project in 1997 (please see the case studies section of Chapter 3 for more information about the project). In the second phase of the project (1999-2004), 6000 consumers will be electrified by solar home systems.

Feasibility Study & R&D on Renewable Energies by IFRD

Recently a project on the "Feasibility Study on R&D of Renewable Energy (Solar, Wind, Micro-Mini Hydro)" has been undertaken by the Institute of Fuel Research Development (IFRD) of Bangladesh Council of Scientific and Industrial Research (BCSIR). The aim of the project is to generate data and information to study the possibility of natural solar, wind and micro hydro power applications in Bangladesh either for water pumping or for generation of electricity particularly in remote and off-shore islands. The small industries may find solar, wind and micro hydropower prospective in remote rural areas or in the islands and coastal region. Acquired technical knowledge from this project will be helpful to develop new technologies in the field of solar, wind & micro hydro, so that the quality of life of the people of coastal, off-shore islands, hilly and other remote rural areas can be improved significantly.

IFRD has established a laboratory for conducting research & testing on solar, wind and micro-hydro equipment.

Solar Energy Component

Solar data (Insolation, temperature and humidity) have been collected for

- i. Dhaka
- ii. Tecknaf
- iii. Sailo propat, Bandarban

Wind Energy Component

IFRD is collecting wind data for the following sites

- i. Saint Martin (offshore island) for the last 2 years
- ii. Tecknaf for 1 year
- iii. Meghnaghat, Dhaka for about 6 months

The maximum velocity obtained at Saint Martins is 20 m/s and yearly average wind speed in 4.6 m/s. The maximum velocity obtained at Teknaf is 16 m/s and yearly average wind speed in 3.8 m/s. IFRD has already imported 3 NEPC 2500, 1100 and 600 Watt wind turbines. The 1100 watt turbine is installed at the sea beach of Tecknaf and 600 watt turbine is installed at Meghnaghat. It has been observed that maximum 600 watt and 200 Watt power has been collected from Teknaf and Meghnaghat respectively.

Micro Hydro Component

There are small waterfalls at Sailo propat, Bandarban and Madab Kunda, Sylhet. BCSIR is conducting pre-feasibility

study for installing micro or mini hydro project at these sites. Flow meters and necessary equipment has already been installed to measure the water flow and head.

Projects by Private Sector and NGOs

RET Programs of Grameen Shakti

Grameen Shakti (GS), or "Rural Energy," was established in 1996 to develop and popularize renewable energy resources. GS has been appreciated globally for its outstanding approach of “micro-credit” for delivering solar home systems in rural areas. GS expects not only to supply renewable energy services, but also to create employment and income-generation opportunities in rural Bangladesh. GS currently has 26 offices in 11 districts of Bangladesh and presently implementing three programs:

- i. Solar Energy Program,
- ii. Wind Energy Program, and
- iii. Biogas Program.

Over the next two years, Grameen Shakti intends to install 20 small battery-charging stations, 20 computer training centers and 20 multi-service centers, all powered by solar energy.

GS has got loan and grant from different bilateral and multilateral development partners including GEF, IFC, USAID, SIDA etc.

Dissemination Program of CMES

The Centre for Mass Education in Science (CMES) was created in 1978 with an aim to take science and technology to the common people of the country. Later on CMES started solar energy related activities in the distant areas of the country through its field offices. It has carried R&D activities on solar cookers, solar water heaters, solar dryers, solar home systems etc. It has recently established its “Solar Lab” to take up adaptive research on accessories of solar PV systems, such as tube light ballasts, charge controllers, inverters, income generating appliances like sewing machines, drilling machines etc. At present, CMES is one of the country’s focal agencies in the “RET in Asia Program”.

Renewable Energy Program of BRAC

Bangladesh Rural Advancement Committee (BRAC) is the largest NGO in Bangladesh and launched its solar energy program in 1997. BRAC started its Renewable Energy Program to electrify remote locations in the country. By the end of 2000, the program has installed more than 500 solar PV systems, 1000 biogas plants, 10 wind turbines, and 260 Hot Box cookers. It has installed 2 grid-interactive PV systems and 6 PV-Wind hybrid systems.

The program involved installing PV systems in its branch offices (training centres, schools, health clinics) and micro-enterprise projects (carpentry, tailoring shop, clothe dyeing, etc.) and in government-owned buildings (rest houses, cyclone shelters, weather-monitoring stations). A few systems have been set up for wealthier households. A limitation of this program is that it is mainly functioning within BRAC’s project boundaries and, to some extent, with government departments.

Projects by Educational Institutions

RET Program of Centre for Energy Studies (CES), BUET

Bangladesh University of Energy and Technology (BUET) created the Centre for Energy Studies in 1986. Main objectives of CES are:

- ✓ To act as a research centre for the dissemination of new knowledge and techniques and to conduct training programs by offering short courses in the field of energy engineering to engineers, scientists, managers, planners, administrators and others.
- ✓ To undertake application oriented research programs on various energy related issues and policies.
- ✓ To carry out fundamental research on the development of energy technologies applied to power plants, solar thermal plants, PV plants, hydro plants, wind plants and others.
- ✓ To establish and promote the linkage of BUET with local and foreign academic, professional and research institutions, agencies, organizations and industries in respect of energy education.
- ✓ To undertake studies and researches sponsored by the governmental and non-governmental agencies and to provide advisory and consultation services to them.

Dissemination of RETs by Renewable Energy Research Centre (RERC)

The renewable Energy Research Centre (RERC) of Dhaka University is carrying out Research, Development and Dissemination activities of different activities from the early 80s. Some of the early studies on wind energy prospects were made by Professor Muhtasham Hussain and his colleagues in this center [Hussain et. al, 1986]. RERC also carried out R&D activities on solar thermal applications.

RERC established and maintains the only solar energy dissemination park named “Energy Park” at the Dhaka University campus. The RERC is also the country focal point of the “Solar and Wind Energy Resource Assessment (SWERA)” Project of United Nations Environment Program. It is expected that after implementation of SWERA, RERC will be even more dynamic in the field of RETs.

Bilateral and Multilateral Development Partner assisted Projects

Sustainable Rural Energy (SRE) Project of LGED

The “Sustainable Rural Energy (SRE)” project has been conceived by LGED within the overall framework of the Sustainable Environment Management Program (SEMP) being implemented by the Ministry of Environment and Forest (MOEF) with financial assistance from the United Nations Development Program (UNDP). The twin objectives of SRE component under SEMP are technology demonstration and technology transfer in the field of renewable energy in Bangladesh. Considering the natural resource base and socio-economic condition, SRE project has considered four

potential renewable energy sources in Bangladesh to deal with: Solar, biomass, wind, and micro-hydro.

SRE has also developed the “Renewable Energy Information Network (REIN)”, with a comprehensive scope for developing an information platform for RETs. This network will be designed and tailored to facilitate the energy planners, project developers, researchers and all relevant organizations in developing RET projects and promotion of renewable energy utilization in Bangladesh.

Renewable Energy Technologies in Asia (RETs in Asia) Program

Renewable Energy Technologies in Asia (RETs in Asia) is a research and dissemination program funded by the Swedish International Development Cooperation Agency (SIDA) and coordinated by the Asian Institute of Technology, Bangkok. The first phase of the regional program (RETs in Asia I) was carried out over a two-year period during 1996 - 1998, while the second three-year phase (RETs in Asia II) started in January 1999.

Basically, RETs in Asia is a Regional Research & Dissemination Program which is to promote the diffusion of selected mature or nearly-mature Renewable Energy Technologies through twelve national research institutions (NRIs) of six Asian countries: Bangladesh, Cambodia, Lao PDR, Nepal, Philippines and Vietnam. The first phase of the program covered three RETs – (1) photovoltaics (2) solar drying and (3) biomass briquetting and briquette stoves.

The main objectives of the second phase of the program are as follows :

- ✓ to conduct applied technical research to adapt RETs to local conditions in selected Asian countries with weak science and technology infrastructure
- ✓ to innovate and implement mechanisms for disseminating RETs in the selected countries
- ✓ to train entrepreneurs and technical personnel with the aim of disseminating RETs
- ✓ to disseminate the results of the Program among policy-makers, with a view to making an impact on the policy process

“Opportunity For Women In Renewable Energy Technology Utilization In Bangladesh” Project by PSL

This pioneering project was initiated in September 1999 with funding from ESMAP as an effort towards demonstrating the capability of rural women from developing countries in engaging as clean energy service providers for their community. Rural women are already the largest users of renewable energy, by virtue of using biomass fuel for cooking, yet their role in modern energy utilization is usually overlooked. This project was designed with a vision that allows the role of rural women to be enhanced by extending their participation in technology based activities.

The project location is Char Montaz, an island with 2000 households, in the southern coastal region of Golachipa

Thana of Bangladesh. Today, 35 rural women of Char Montaz are engaged in the operation of a micro-enterprise for construction and sale of DC lamps, which can be used in combination with batteries in Solar Home Systems (SHS). With continued training from this project, the women learnt lamp construction with quality control, business development and marketing. Today more 1000 lamps are being used with re-chargeable batteries for lighting the rural houses, shops, mosques and fishing boats.

As a significant contribution, this activity has removed some of the social and cultural discrimination associated with the gender role to be played by women, an opportunity aimed towards poverty alleviation. Overall impact to be achieved from this project has far-reaching potential not limited to the direct participants only, since the benefit of improved environment extends with every new household that adopts modern lighting.

The project has entered its second Phase in 2002 where the objective is to:

- ✓ expand the scope of income generation for women. In addition to on-going DC lamp assembly, enhance the manufacturing capacity to assemble state-of-the-art charge controllers for solar home systems for the upcoming national projects.
- ✓ expand the market for off-grid DC lamp and battery service to a larger area so that more rural people can experience the benefit of modern lighting,
- ✓ demonstrate financial viability of solar electrification service for dispersed households that are too distant for grid and micro-grid alternatives.

BUET- Loughborough University Higher Education Link Project

The major objectives of the project are to develop the curricula and to conduct several research activities on different RETs. The linkage program is funded by DFID, UK through the British Council, Bangladesh. This is a 5-year project started in April 1999.

Projects so far completed:

- i. Study of potential of energy in river current of Bangladesh.
- ii. Development of a model water current turbine for harnessing the energy from river current.
- iii. Modeling a hybrid PV-Wnd system for the rural application in Bangladesh.

On-going projects :

- i. Development of a prototype water current turbine.
- ii. Arsenic removal from drinking water using solar energy.

Workshop/Conference organized:

- i. Short course on Photovoltaic Technology for Bangladesh, 12-16 March 2001.
- ii. International Conference on Renewable Energy for Rural Development, 19-21 January 2002.

Solar and Wind Energy Resource Assessment (SWERA) Project

In most of the developing countries, renewable resource information is absent or inadequate. This is one of the major barriers for wide-spread deployment of RETs in these countries. Understanding this obstacle, UNEP is carrying out a 3-year (June 2001 to July 2004) long "Solar and Wind Energy Resource Assessment (SWERA)" project with GEF fund. SWERA will start with the following countries - China, Bangladesh, Sri Lanka, Nepal, Ghana, Kenya, Cuba, Honduras, El Salvador, Nicaragua, Algeria, Brazil and Guatemala. The overall goal of this project is to promote the integration of wind and solar alternatives in national and regional energy planning and sector restructuring as well as related policy making. The project will enable informed decision making and enhance the ability of participating governments to attract increased investor interest in renewable energy.

Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement Project

The Asian Development Bank (ADB) approved a Technical Assistance (TA) for the Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement (PREGA) project on 4th January, 2001. The TA will be confirmed by the Government of the Netherlands on a grant basis in an amount not exceeding US\$ 4,500,000 and by the ADB on a grant basis in an amount not exceeding US\$ 500,000. The ADB will administer the contribution of the Government of the Netherlands. The TA will be implemented by ADB in two stages over a three year period, commencing in January, 2001 and ending in December, 2003. An initiating workshop was convened in April, 2001 at which approaches to preparing Country Work Plans (CWPs), among other items were discussed. A National Implementation Committee (NIC) has been formed under the Ministry of Energy and Mineral Resources (MEMR) to carry out the tasks of PREGA.

Objectives

The main objectives of PREGA are :

- ✓ To promote investments in renewable energy, energy efficiency and greenhouse gas abatement (REGA) technologies that will increase access to energy services by the poor, reduce GHG emission and realize other strategic development objectives,
- ✓ to generate a pipeline of investment projects for financing through commercial, multilateral and bilateral sources including specialized treaty linked mechanisms such as Global Environment Facility (GEF) and CDM,
- ✓ to identify policy and institutional barriers to dissemination of REGA technologies and
- ✓ to study and develop financing models for REGA investment projects.

Country Work Plans (CWPs)

CWP will be prepared in consultation with the relevant

agencies of the Developing Member Country (DMC) Government, multilateral and bilateral development agencies with active REGA programs in the participating DMC. Private sector industry associations and other stakeholders, all of which will be consulted as a national Implementation Committee (NIC). ADB Has Already Appointed Bangladesh Centre For Advanced Studies (BCAS) As The National Technical Expert (NTE) For The PREGA Project.

Rural Electrification and Renewable Energy Development Project

The blended IDA/GEF Bangladesh Rural Electrification and Renewable Energy Development project supports the Government's development strategy to increase rural electricity access, and thereby promote social development and economic growth.

This objective is sought to be achieved in the following four ways :

1. Assisting the REB to expand and intensify rural grids, improve the operational and financial performance of the rural co-operatives (known as PBSs), and reduce power outages in the rural grid systems
2. Facilitating development of decentralized, mini-grids, based on natural gas, diesel, wind and hydro sources where feasible
3. Promoting use of solar home systems in rural areas inappropriate for grid expansion
4. Increasing productive use of electricity and enhancing poverty impacts.

The project defines the institutional models, the stakeholders and implementing agencies, and financing and implementation details developed to place the renewables component within the context of a larger rural electrification strategy for Bangladesh. The blend IDA/GEF project will support this strategy, and a part of the IDA credit will be employed to promote large-scale application of renewables with investment and technical assistance resources.

(i) Establishment of a SHS based pre-electrification program for PBSs

The project will enable REB and five PBSs to develop a 'fee-for-service' SHS market and install 14,000 SHS in rural households on this basis. IDA and Government will provide credit resources, with GEF grants to finance the SHS program. Besides investment funding, TA resources are to be provided to strengthen institutional capacity, develop a sustained 'fee-for-service' PV market, provide implementation support and training, establish arrangements to test and certify equipment, monitor project progress, establish and operate a socio-economic cell in REB to design, implement and evaluate programs to use electricity to increase rural incomes and social well being, and establish sound performance monitoring and evaluation methods.

(ii) Establishment of a SHS credit line and TA to support private sector, NGOs and MFIs

The project will specifically support capacity building of

private sector, PBSs, NGOs and MFIs to enter into and implement solar development programs. Capacity building would include generating awareness about solar based opportunities, disseminating information widely and effectively, developing skills among 'institutions' and 'people' to implement and manage the program and training for solar technicians, community mobilizers and microfinance practitioners. The project envisages GEF financed TA, matched by IDA and Government, for market development and solar promotion. To overcome financing barriers, a renewable energy credit line from IDA resources and a GEF cofinancing grant is proposed to be set-up and operated by the Infrastructure Development Company Limited (IDCOL) on commercial terms to finance 50,000 SHS. IDCOL will on-lend to MFIs (or NGOs as the case maybe) and solar businesses to facilitate the purchase of solar home systems by consumers.

(iii) Development framework for other renewables

The project will provide support for assessment of wind resources in the coastal areas of Bangladesh and for run-of-the-river mini hydros in the hilly regions. If assessments indicate positive potential, IDA would support development and implementation of pilots to confirm commercial feasibility. Support will in that case be extended to formulate a policy framework for commercial development of these resources, including development of Small Power Purchase Agreement (SPPA) and incentives.

Promotion of Renewable Energy in Selected Rural Areas of Bangladesh

The main objective of the project is to test, promote and disseminate renewable energy in selected remote areas of Bangladesh. The project period is 3 years and estimated cost is DM 4 million which will be funded by GTZ of Germany. GTZ has selected Bangladesh Rural Electrification Board as the implementing agency of the project. To achieve the project objective, the following five project outputs have been proposed by GTZ :

- ✓ Support of establishing an institutional framework for co-ordination of renewable energy activities at national level and facilitating development of suitable strategies
- ✓ Adaptation and promotion of appropriate technologies for productive use of renewables in small-scale enterprises
- ✓ Private sector based marketing, production, maintenance and recycling systems for renewables
- ✓ Sustainable access to renewable energy services for selected self-help groups and social service providers at community level (e.g. schools, rural health clinics, cyclone shelters)
- ✓ Strengthening of technical and management capacities of major implementing agencies.

9. Barriers

There are plenty of barriers hindering the widespread deployment of potential RETs. Different types of barriers experienced from the past are described below.

Policy Barriers

- Lack of financial incentive policies to encourage renewable energy development
- Lack of legal, regulatory and policy framework for market oriented renewable energy programs. Most of the renewable energy programs in Bangladesh are primarily technology-driven and focus on R&D, rather than emphasize promotion and encouragement of commercialization and private sector involvement.
- Unfavourable utility regulations to renewable energy development (lack of standardized power purchase agreement).

Institutional Barriers

- Renewable energy based provision of modern energy services is dealt with by various ministries, agencies and institutions, making good coordination between them a necessity to efficiently make use of limited human and financial resources in this area.
- Lengthy and difficult process for permission.
- Dependency on the national budget for implementation of activities, which creates uncertainties in allocation of project financing as well as time delays associated with decision making.
- Limited spatial distribution of suppliers limits access to renewable energy technologies.

Technical Barriers

- Lack of standards and quality control for renewable energy equipment.
- Lack of domestic manufacturing.
- Difficulties of firm dispatch in utility grid operations.
- Bulk procurement of renewable energy technologies is limited due to the current small market for renewable energy based modern energy services. Hence the (technical) infrastructure to support renewable energy development does not exist.
- Local manufacturing and/or assembly of renewable energy technology components are currently very limited, although the knowledge, skills, expertise and facilities are available in the country.
- Limited technical capacity to design, install, operate, manage and maintain renewable energy based modern energy services, mainly as a result of lack of past activities in this new field.

Market Barriers

- Limited knowledge on the renewable energy market potential.
- The high upfront cost at the end user level for renewable energy is a major barrier to the increased use of renewable energy sources for the provision of modern energy services.
- Market distortions by subsidies or grant-based hardware installation programs.
- No dedicated financing for renewable energy activities exists with financial institutions now. The capacity within

the financial institutions and power utilities to appraise renewable energy proposals and requests for loan is limited or non-existing;

- Government budgets for subsidizing RE projects are limited as the demand for financing the various national priority areas (health, education, disaster management etc.) is great.
- The currently small and dispersed size of the renewable energy market in Bangladesh does not facilitate benefits such as economies of scale.
- Availability of renewable energy resources is very site specific, requiring detailed analysis of the local specific conditions.

Economic, Financial and Financing Barriers

- Below loan-run marginal cost pricing and price distortion.
- High initial capital costs.
- Higher perceived risks of the renewable energy technology.
- Financial institutions biases and unfamiliarity with financing renewable energy projects.
- Lack of access to credit.
- Lack of appropriate financing mechanisms for renewable energy.

Information Barriers

- Lack of information about renewable energy resources, technical/economic information about RETs, equipment suppliers, and potential financiers.
- Lack of awareness of renewable energy in public, industry, utility, financial institutions and policy-makers.
- Availability and access to existing renewable energy resource information is limited. A central information point does not exist, instead information is scattered among various sectors; e.g. public sector, development assistance, R&D Centres and academia.
- There is lack of public awareness on renewable energy technologies other than that they exist. For example, knowledge that the life cycle costs of most renewable energy technologies are often competitive or even lowest among cost options is mostly absent.
- Little empirical knowledge on the costs and benefits of the range of technologies available for providing renewable energy based modern energy services exists and thus it has not been extended to policy and decision making level.

Human Resource Barriers

- Limited expertise in business management and marketing skills
- Limited in-country capacity for renewable energy data collection and analysis.
- Lack of expertise and services in system design, installation, operation and maintenance of renewable energy technologies.
- Limited in-country capacity for renewable energy project development.

10. Concluding Remarks

It has been made clear from the previous paragraphs that Bangladesh is already strongly dependent upon traditional renewable energy technologies and notable initiatives have been taken to popularize modern RETs by different agencies. The Renewable Energy Programs of Grameen Shakti has become highly acclaimed among national and international policy makers, bilateral and multilateral development partners and by the RET enthusiasts. The “Opportunity For Women In Renewable Energy Technology Utilization In Bangladesh” project has also been identified as an innovative approach for dissemination of RETs with the participation of rural women. It is expected that the GEF funded “Rural Electrification and Renewable Energy Development Project” will also accelerate the growth of RETs utilization in the country. RETs are slowly finding a niche market in Bangladesh. But still there are lots of barriers and the expected outcome from the past initiatives are not encouraging as the total utilization level is meager. The RET field of the country is not transparent as most of the players are unwilling to share their experience or strategies. Only during national or international workshops and seminars, outsiders or the general audience are able to know some of the experience from their refined presentations. There is no coordination among different implementors and it has been seen that same tasks were done by different groups resulting wastage of scarce resources. Time-bound targets for mass dissemination of different renewable energy technology options have to be adopted by the Government of Bangladesh (GOB) for fulfilling its obligation of universal electrification program by the year 2020. The draft Renewable Energy Policy, submitted by the Power Cell, should be approved by the GOB immediately and Renewable Energy Development Agency (REDA) should be created to act as a focal point in the renewable energy sector of Bangladesh. REDA should be dedicated to remove the barriers prevailing in the renewable energy sector of the country.

Acronyms & Abbreviations

BAU	Bangladesh Agricultural University
BCSIR	Bangladesh Council of Scientific and Industrial Research
BIT	Bangladesh Institute of Technology
BPDB	Bangladesh Power Development Board
BUET	Bangladesh University of Engineering and Technology
CMES	Centre for Mass Education in Science
CUET	Chittagong University of Engineering and Technology
DU	Dhaka University
GEF	Global Environment Facility
GOB	Government of Bangladesh
GS	Grameen Shakti
IDCOL	Infrastructure Development Company Ltd.
IFRD	Institute of Fuel Research & Development
IPP	Independent Power Producer
KUET	Khulna University of Engineering and Technology
LGED	Local Government Engineering Department
MEMR	Ministry of Energy and Mineral Resources
NEP	National Energy Policy of Bangladesh
NGO	Non-governmental Organization
PBS	Palli Bidyut Samity (Rural Electricity Co-operatives)
PV	Photovoltaic
RUET	Rajshahi University of Engineering and Technology
REB	Rural Electrification Board
REDA	Renewable Energy Development Agency
RERC	Renewable Energy Research Centre
RETs	Renewable Energy Technologies
SHP	Small Hydro Power
SHS	Solar Home System
SRE	Sustainable Rural Energy
TA	Technical Assistance
WB	World Bank

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