Chapter2

Sustainable rural energy in Bangladesh:

A multistakeholder and multidimensional approach towards mainstreaming renewable energy technologies

.Aminul Islain[1]

Abstract

Bangladesh has a wide variety of renewable energy resources.While 55 percent of energy supply is based on traditional fuels, currently about 88 percent of power generation is based on natural gas.However,70 percent of the population does not have access to electricity. Since 65 percent of the population lives in rural areas, sustainable rural energy (SRE) development is vital.The SRE project framework is owned by the inistry of Environment and Forest (oEF),with financial assistance from UNDP,while projects are implemented through the Local Government Engineering Department (LGED). To achieve a community-based model of development, there are three categories of activities performed under SRE projects demonstration of renewable energy technologies (RETs) capacity building and the development of renewable energy information.At the end of the project's implemen-tation programme,widespread demonstration and dissemination of the RETs in the off-grid areas are expected.In the longer term,the technologies will also provide support as sustainable commercial activities.The SRE activities promote pro-poor, self-sustaining projects and community empowerment. The government is also taking parallel steps to ensure the replication of RETs,through the offices of the LGED located nationwide.However,since activities carried out under the SRE framework are merely for demonstration purposes,it is difficult to assess the cost effectiveness of the project.

Keywords: Sustainable rural energy,renewable energy technologies,solar electrification,community empowerment.

1. Context and background

About 55 percent of the energy supply in Bangladesh is based on traditional fuels (crop residues,animal dung and fuelwood) 2 natural gas 1 percent on imported oil and coal and the remaining two percent on hydroelectricity. Currently about 88 percent of power generation is based on natural gas.Presently,70 percent of the population does not have access to electricity and it is unlikely that they will have access to electricity in the foreseeable future.Annual per capita energy consumption is approximately 100 kgoe (kilograms oil equivalent),which is among the lowest in the world.Using the rule of thumb that each percentage of GDP growth will require 1.5 percent growth in energy use,the 7– percent growth that Bangladesh aspires to would presuppose 10–15 percent annual growth in energy use. This situation calls for adoption of sustainable energy strategies that permeate at all levels of the economy and provide the people with the services that they want.

Bangladesh is endowed with a wide variety of renewable energy resources and possesses the potential to cater to the unmet demand for energy for socio-economic development. eeting the challenge of poverty alleviation requires attention to ensure access to energy with a focus on the inter-relationship with energy

1 Sustainable Development Adviser UNDP,Bangladesh.

energy interacts with all aspects of social and economic development,including livelihoods,water, agriculture,population,health,education,job creation and gender-related issues.

The development of rural energy resources provides an opportunity to widen the productive sphere of the rural economy,thus contributing to the national efforts of improving the living standards of the rural poor,as 65 percent of the population lives in rural areas.At present, rural people lack access to energy services even for meeting their cooking needs.The burden of managing household energy is increasing day-by-day,and falls disproportionately on women and girls.Biomass fuel accounts for 76.3 percent of the total fuel consumption in rural industries such as paddy parboiling,smithies and potteries and is the common fuel in rural households. Only ten percent of the rural population is connected to the electric grid network. oreover electricity is too expensive to be used as a cooking fuel. It is mainly used for lighting, listening to the radio and watching television.Villagers who do not have electricity use kerosene lamps,which provide poor illumination thus time for study at night is inadequate. This seriously limits educational improvement,besides causing respiratory and eye ailments.

Institutional, policy, market and tec nical barriers ave impeded t e adoption of RETs.

Concerns have been raised about the current patterns of energy production and consumption that significantly contribute to environmental degradation at the local,regional and global levels.Since access to modern energy services is viewed as an essential prerequisite for increasing productivity and improving people's livelihoods,UNDP has had significant involvement in developing the energy sector through capacity development,technology access,policy innovation, properly designed market mechanisms,integrated energy and development solutions and new partnerships with energy investors.

2.Genesis of the Sustainable Rural Energy (SRE) project

Apart from conventional energy sources,there has been a move towards finding a cleaner and more efficient energy source,especially in the rural sector.

The renewable energy sources that are available include solar,wind,biomass and microhydro. The average solar radiation in Bangladesh ranges from .0 kWh/m² in winter to 6.5 kWh/m² in summer. The average monthly wind speed in the coastal regions ranges from 2 to 5 m/s at 25-metre height.There is considerable potential for RET applications in Bangladesh.For example,there is the potential for four million household-based biogas plants as the country is primarily dependent on the agriculture sector,according to the Institute of Fuel Research and Development (IFRD). A survey carried out by the World Bank has found that there is an existing market potential of 0.5 million households for Solar Home Systems (SHS) on a free-for-service basis in the off-grid areas.Currently,the national grid only covers 50 percent of the approximate 100,000 rural markets and rural centres – the remaining sites are excellent candidates for the centralized solar photovoltaic plants.The World Bank study has further found that 82 percent of the diesel operators serving most of the off-grid rural markets are interested in marketing SHS in the surrounding areas.

Despite the natural endowment of such resources,Bangladesh is at the very early stage of utilization of non-conventional and renewable energy resources. Various institutional,policy, market and technical barriers have impeded the adoption of RETs.Technical barriers such as the limited in-country capacity for resource assessment,system design, installation, operation and maintenance (O&) have impeded the application of the renewable energy resources. odern RETs are still in the research,development and demonstration phase *(see Annex 2-1)*.Bangladesh Atomic Energy has undertaken RET projects since 1 85,however these projects were not targeted towards the communities in the remote areas.Grameen Shakti is currently implementing various renewable energy projects but their activities are based on credit systems.The users have to buy the system either on a cash or credit system.

In contrast to the projects carried out earlier,the SRE project promotes pro-poor,self-sustaining projects.Several renewable energy options are being considered for implementation under the SRE project,with a focus on demonstration of the

sustainability of the technologies.This will provide poor and marginalized groups with increased access to energy services.

3.Design of the SRE project

The SRE project has been conceived within the overall framework of the Sustainable Environment anagement Program (SE P) being implemented by the oEF with financial assistance from UNDP.The component is being implemented by the LGED.The objective of this component is the development of community-based models for sustainable practices of renewable energy as an alternative source of clean rural energy in off-grid areas.The specific objectives are the demonstration of RETs and capacity building for technology transfer as well as wide dissemination of these technologies to mainstream them as sustainable long-term commercial activities.

The focus of the SRE is multidimensional and involves four potential renewable energy sources solar,biomass,wind and microhydro.The activities under SRE projects can be grouped into three main categories

Figure 2-1:RET demonstration under Sustainable Rural Energy (SRE)

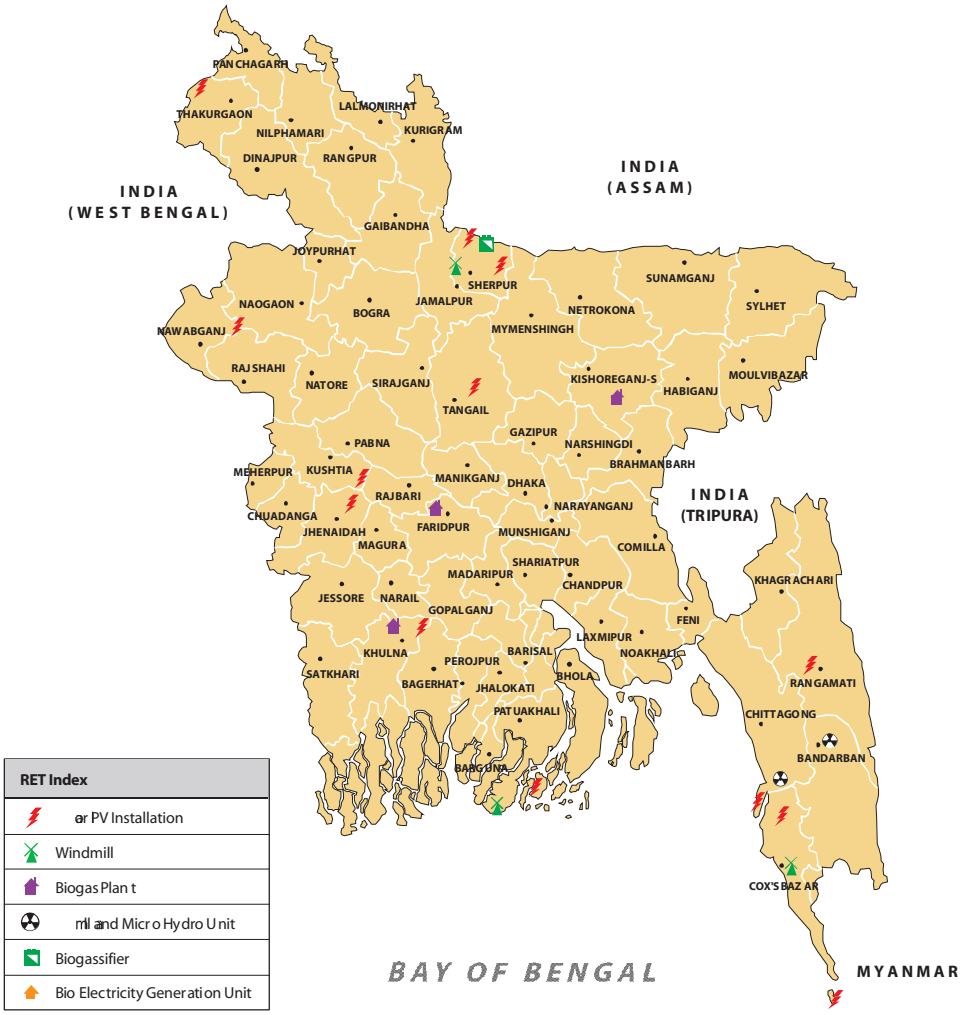

Table 2-1:Renewable Energy Technologies (RETs) in Bangladesh and their salient features under the UNDP-supported SEMP SRE component

Type of RET	Project name	Year of installation	System capacity	Beneficiary	Total cost (US$)
Solar Energy System	Solar Home Lighting System	1	2,625 Wp	35 households	1, 80
	Centralized Solar Electrification (AC) for Growth Centre	1	1,800 Wp	50 shops,2 small industries and a mosque	3 ,000
	Cluster Village Solar Electrification	1	1,725 Wp	60 families (homeless people)	2 ,200
	Solar PV System for Goznee Tourist Spot	1	225 Wp	Tourists	3,500
	Solar Water Purifier in LGED HQ	1	150 Wp	LGED officials	
	Solar Electrification in Rural Clinics	2001	1,500 Wp	Rural people at amarul, hulna (30 000 people)	15,850
	Solar Electrification at Ambaria UP Complex Bhaban	2001	600 Wp	Chairperson of UP (local governance),members	10,275
	Solar Home Lighting System for Tribal Community and Buddha Temple	2001	1,080 Wp	15 tribal families and a Buddhist temple	1 ,160
	Solar electrification for IT development	2001	375 Wp	Upazilla Engineer's Office	6,200
	Centralized Solar AC System for Fisherfolk Communities	2002	5,000 Wp	Coastal fisherfolk communities	0,000
Wind Energy Development	Low Speed High Torque Windmill	1	15,000 litres/day at m/ wind with starting speed 1.8m/s	Irrigation,gardening, freshwater for coastal tourist resorts	2,650
	Solar-wind Hybrid System	2000	0 Wp	Tourists	2, 50
	Wind Energy Resource apping				
Bio-energy Development	Community- based Biogas Plant	1		Community members (around 150 families)	8, 25
	Biogas plant for educational institute	2002 (ongoing)		Students, teachers and local people	8, 25
	Bio-electricity Generation from Poultry Waste	2002		Students,teachers	10,000
icrohydro Energy Development	Proposed microhydro power unit	2003	10 kW	Agricultural farms	
	Development of an in digenous micr ohydro unit and harnessing small/micro potentials	2002 (ongoing)			

•Demonstration of RETs
•Capacity building through training on RETs
• Development of the Renewable Energy Information Network (REIN).

The O& for the various projects is case-specific and is carried out by the beneficiary.In most cases however,the community,being the beneficiary, is responsible for the smooth operation of the system.Beneficiary training is also being provided for assisting in the operation of the various systems.Funds for periodic maintenance will be mostly borne from the money contributed by the beneficiaries.For example in the case of the solar home systems for household application, the maintenance expenditure will come from the contributed initial down payment and monthly payments received from each household.

3.1 Solar energy-based technologies

The introduction of solar photo-voltaic systems and their increasing use worldwide is a major step towards an ecological and sustainable energy system. It is a more environmentally friendly technology than any other means of generating electricity,making power available anywhere thus the current prohibitively expensive process of extending electrical grids everywhere is avoided.Their modular nature,low maintenance and availability make this new and emerging power source an attractive alternative for its large-scale usage in rural areas.

Community-based biogas plants not only provide an alternative source of energy but also improve the health and sanitation of the community.

3.2 Bio-energy-based technology

Apart from the LGED's own initiatives on the construction of biogas plants,two Upazillas[20] (subdistricts) have been selected as project areas on a pilot basis under the SRE component.The community-based biogas plants not only provide an alternative source of energy but also improve the health and sanitation of the community. All families are provided with improved sanitary latrines connected with a central digester.The demonstration plant benefits the community in many ways providing energy for cooking and thereby saving fuelwood,ensuring better health and sanitation for the community and also providing good quality pathogen-free fertilizer for agricultural use.From the community,a beneficiary committee has been formed and this committee is entrusted with the proper O& of the system.

In Faridpur,the poultry project of the ission constructed a poultry house of about one thousand square feet involving 5,000 birds.An electricity generation unit from poultry waste has also been set up at Faridpur.Currently,installed power generation is kW,but it is hoped that this will increase to 10 kW.The children of the ission are provided with hands-on training.The eggs and owls supply nutrition to the residents. After completion of the project the system will be handed over to the management committee, who will be responsible for the O& of the power unit. If successful,this project could be replicated throughout the country and contribute significantly to the energy sector.

3.3 Wind energy technology

Wind energy is in the early stage of application.Several locations have already been assessed to evaluate the wind energy potential of the coastal region. The scope of utilization of wind energy resources can become effective in certain cases of exclusive applications during wind water pumping and power generation through wind-diesel hybrid systems at suitable locations.The installation of two water-pumping windmills and one wind-solar hybrid system has already taken place.

Under the SRE project,in collaboration with BUET (Bangladesh University of Engineering and Technology) and BIT (Bangladesh Institute of Technology),Chittagong has also started a study on wind resource mapping.The study has been designed in a comprehensive manner, aiming at systematic observation on wind regimes at 20 suitable locations including the Chittagong Hill Tracts over a longer period of time.

20 Upazilla means sub-district.It is a government administrative centre at the local level.An upazilla comprises several unions and a union comprised of several villages.

3.4 Microhydro plant

Bangladesh is a riverine country with three main rivers the Ganges,the Brahmaputra and the Jamuna.About 1. [illegible] ^{3} of water flows through the country in an average water year. Numerous rivers flow across the country,which are mostly tributaries of these main rivers leading to immense hydropower potential.At present only 230 W of hydropower is utilized in arnafuli Hydro Station,which is the only hydro-electric power plant operated by Bangladesh Power Development Board (BPDB).Several attempts have been made in the past to find out the potential of small and microhydro power units, which are believed to be more environmentally or ecologically friendly in comparison to large hydros with dams.

Through the SRE project,assistance has been provided for the development of indigenous microhydro power units. oreover,the installation of a 15kW microhydro unit at Bamerchara under Banskhali thana in Chittagong District is under consideration.

3.5 Renewable Energy Information Network (REIN)

The development of an information network for a renewable energy database and its maintenance is the key activity of REIN.This network has been designed and developed to facilitate the energy planners, project developers,researchers and all relevant organizations.REIN is designed to work as an information platform for compilation of data in the following four categories

- Resource Database The database is a compilation of information on the national resources relevant to RETs.The major categories of the resource database available include not only renewable energy resources but also human resources,and logistical resources
- Renewable Energy Projects Assistance provided for the development of renewable energy projects
- Research and Development Information about completed and ongoing research and development projects will be put online
- Information edia Periodic newsletters on renewable energy are posted online by the SRE summarizing the impact and status of renewable energy project activities in Bangladesh.

T e development of an information network for a renewable energy database and its maintenance is t e key activity of REIN.

3.6 Training for capacity building and technology transfer m

Required training programmes for capacity building and technology transfer are provided through the project's activities.The novelty of the technologies demonstrated in this project demands a sound plan for training and capacity building.Activities have been undertaken to ensure user-training, technician-training,training-of-the-trainers as well as institutional capacity building.Systematic maintenance and proper use of the systems on a daily basis ensures minimum repair and maintenance work.The users of the systems are provided with written and illustrated guidelines safe usage.The local technicians are responsible for the day-to-day troubleshooting and other maintenance-related work.For the long-term sustainability of the programme, trainers have been trained to meet future training needs and are prepared to offer training to the users in the community on the operation of the community-based systems.

3.7 Expected end result according to the project document

At the end of the project implementation programme, it is expected that there will be widespread demonstration and dissemination of the RETs in the off-grid areas.The impact of such activities will be the mainstreaming of such technologies as sustainable long-term commercial activities.

4.Implementation of project activities

Some of the pioneering efforts carried out by the project are described below

4.1 Solar electrification in cluster villages

The SRE project built on the ongoing government priority programme Asrayan (shelter for the homeless) through solar electrification in cluster villages for the landless poor.The objectives are twofold first to assess the potential of the technology in improving the quality of life of the landless poor and second to verify whether

the landless groups can organize themselves to support O& of the system.The installation has been successfully completed in Nalitabari *Upazilla*[21] in Sherpur District providing solar electricity to 60 houses of the landless poor this has been operating smoothly for the last one-and-a-half years.It also demonstrates the capacity of the landless poor to maintain the technology,which contributes to improving their quality of life.

4.2 Centralized solar market electrification

For the first time in Bangladesh,the SRE project has successfully completed solar market electrification in a rural market at Gangutia under the *S oilkupa Upazilla* in Jhenaidah District.The objective of this scheme is to install a demonstration plant of a centralized solar photovoltaic system for electrification of a rural market in the off-grid area and to assess its technical and economic viability in the context of rural Bangladesh.

4.3 Gangutia growth

This site has been selected for solar electrification because of its remote location (the nearest grid extension is around seven kilometres away).The system has the capacity to produce 1.8 kW of power with a daily consumption of 2,000 watt-hours, providing lighting to three food-processing small industries,one health centre and one bazaar mosque.O& have been entrusted to a local NGO,Shuboshoti.Each consumer is paying Tk.[22] .00/day which is adequate enough to support major maintenance requirements like replacement of CFL lamps and batteries at regular intervals.The total cost of market electrification is around Tk.11 *lak s*[23].The successful installation of solar market electrification has created great enthusiasm among the local villagers and it will be a milestone for the green energy movement in the country.

T e installation of solar electricity system in t e village also demonstrates t e capacity of t e landless poor to maintain t ec nolgy, w i c ontributes to improving t eir quality of life.

5.Lessons from implementation of the SRE under the LGED

5.1 Reaching the poorest of the poor

The project has been designed to have a pro-poor focus in the off-grid areas,which are often the least developed.It is unlikely that in the foreseeable future the majority of this population will have access to electricity,especially in the far-flung areas.Thus the lack of energy sources has a negative impact on the development of these regions.The project has therefore provided new and inventive methods for the provision of non-traditional energy sources in such areas.

5.2 Ownership to the community

In almost all cases,the stakeholders of the project are the members of the community.Community building has been emphasized since the beginning of the project through the participatory approach.The project is designed to eventually hand over the plants to the beneficiaries.The beneficiaries will therefore take greater care in their maintenance and increase the lifespan of the RETs.

Community ownership thus promotes community empowerment it allows greater integration among the members of the community to achieve a common goal.For example,the solar electrification of the bazaar in Jhenaidah provided a means for building community spirit. It allowed the beneficiaries to gain the benefits of the electrification collectively.

5.3 Sustainability of the operation

All initiatives are designed in a manner that allows UNDP to exit without hampering their effective operation.The activities are designed to be self-sustaining the community,which is often the stakeholder, is able to continue with the operation of the plants after the project ends.

21 An average upazilla population is approximately 200,000.

22 US 1.00 = Taka (Tk.) 58 (approx).

23 1 lakh = 100,000.

Since technical training is provided to members of the community,smooth operation of the systems is thereby ensured.A system has been set up for regularly collecting funds contributed by the beneficiaries.The necessary funds for the O& of the systems are therefore borne by this contributed money and do not pose an extra burden.

5.4 Economic empowerment as a result

Economic empowerment is being gained by the poorest of the poor due to the activities of this project.For example,the demonstration of a microhydro unit in Chittagong will improve the quality of life and provide income-generating activities.Women are also being empowered as the light is providing them with the opportunity to earn a livelihood.Earlier,the extent of their activities was determined by the presence of sunlight with sunset,their day was more or less over.But now they can continue with their daily activities,as well as pursue income-generating activities in the evenings and at night.Also centralized solar electrification of the market at Jhenaidah has led to an increase in the daily market activities and boosted rural economic activities.

5.5 Social change brought about in the communities

A social change is being brought about due to the availability of an alternative energy source.People are gaining greater knowledge about the subject and are also showing interest in the renewable energy sources. There is a mushrooming of the RETs in the areas surrounding the demonstration sites,indicating the demand for such technologies.Replication by the NGOs can lead to greater dissemination of the ideas.

The government-run evening adult education classes have benefited greatly from the project due to the extension of active hours as a result of electrification. There is improvement in the healthcare provided in rural areas through the presence of an alternative energy source.Solar-powered refrigerators can preserve vaccines,blood etc,while solar-powered lights can be used in operating theatres.

5.6 Provision of a cleaner energy source

Usage of a cleaner technology is reducing the pressure on the environment.Especially in the rural households,the pressure on the biomass was high due to traditional energy sources such as the burning of wood for fuel.The provision of an alternative energy source therefore benefits the environment by reducing the need for burning wood to provide energy.A decrease in the use of diesel for electrification in the project areas also has a positive impact on the environment.

5.7 Removal of the information barriers through the establishment of REIN

The information barriers that were present arlier due to the lack of availability and access to information sources have been diminished considerably because of the establishment of REIN. The publication of a newsletter/brochure on RETs provides greater information sharing on this subject both among the producers as well as the consumers of these technologies.

There is improvement in the healthcare provided in rural areas through the presence of an alternative energy source.

Through REIN's multistakeholder approach,the interaction of the providers as well as the consumers of the RETs has been facilitated.Up-to-date information is being provided not only about the inputs but also about the organizations that are involved in the renewable energy practices.There is now greater awareness regarding the costs and benefits of the range of technologies available for providing renewable energy-based modern energy services.

5.8 Training on non-renewable technologies allows more effective maintenance

Technical barriers for the implementation of sustainable rural energy practices have been broken down.Personnel who design,install,operate, manage and maintain renewable energy-based services are available owing to the training provided under the SRE project.While the training has been provided to a limited number,in the current country context this is still a major step leading to greater national capacity development.

5.9 Drawbacks to the project

Since the activities carried out under this component were merely for demonstration purposes,it is very hard to assess the cost effectiveness of the project.

The activities were also conceptualized under ideal conditions therefore more demonstrations need to be carried out in order to find out the institutional constraints of the activities.

Although the demonstrations have taken place in off-grid areas,their applicability in grid areas also needs to be noted.

5.10 Replication initiatives

Interest in sustainable renewable energy practices is high as can be seen by their replication in the areas surrounding the demonstration sites.There is considerable scope for the government to tap into this alternative energy source.NGOs specializing in renewable energy,which are already involved in this sector,could be instrumental in the replication process and thereby aid the development of the energy sector.Due to the overwhelming dependence on biomass-based energy consumption in rural areas and the depletion of bio-diversity,the situation is becoming critical.The only alternative to prevent catastrophe is to opt for renewable energy.

As a result of the activities of this component, which focuses on decentralized community-based renewable energy in multipurpose applications,the government is also taking parallel steps to ensure the replication of RETs.Through the numerous offices of the LGED located throughout the country,there is greater opportunity for the RET applications to be duplicated.

T e financial institutions lack t eapacity to appraise renewable energy proposals and loan requests and udge t eir viability.

5.11 Existing barriers to the widespread adoption of the RETs

Policy barriers There is a lack of financial incentive policies to encourage renewable energy development.Legal,regulatory and policy framework mechanisms for the market-oriented energy programmes are missing.

Institutional barriers ost of the renewable energy programmes are primarily technology driven and the focus is on R&D rather than promotion and encouragement of commercial and private sector involvement in RETs.The lack of coordination between the different ministries,agencies and institutions that deal with the RET sector makes the widespread dissemination of RETs problematic.

arket barriers The high initial cost at the user level is a considerable market barrier to the increased use of renewable energy sources.

Financial barriers No dedicated financing is presently available in financial institutions for renewable energy activities.The financial institutions also lack the capacity to appraise renewable energy proposals and loan requests and judge their viability.

5.12 Future scenario – case study follow up

As part of the exit strategy of this component, emphasis has been put on noting the successes of the various demonstration projects and aiming future endeavours at mainstreaming these activities. It has been suggested that the Solar Home Systems that have proved to be so successful should be mainstreamed in the future.Similar mainstreaming programmes are also being envisaged for Biomass Gasifiers, Solar Thermal Systems and SPV pumping systems.Detailed programming for such mainstreaming is currently being worked out.The programme would include some aspects of financial support to alleviate the initial high cost of installation.

As a follow up to the activities of this component,UNDP Bangladesh is in the process of formulating a pro-poor environmentally friendly energy programme aimed at achieving energy efficiency,energy conservation and promotion of RETs. There is a need to focus on poor people's energy needs,and frame energy in the development process.

While Bangladesh has traditionally focused on sectorally-based mega projects,a shift is needed from the sectoral- and technology-driven approaches to one which embodies energy as a basic need for the poor.The programme will thus focus on improving access to energy services that meet people's needs and priorities,focusing on the "un-served"and poor through public-private partnership and involving local governments and NGOs.

Emphasis will also be put on promoting a decentralized energy system as well as examining in greater detail the different relationships involving energy such as the poverty-environment-energy nexus.

Bibliography

Bangladesh Centre for Advanced Studies (BCAS). 1 *iffusion of renewable energy tec nologies* Dhaka,BCAS.

Biswas,Wahidul K;Bryce,P.& Diesendorf,M. 2001. odel for Empowering Rural Poor through Renewable Energy Technologies in Bangladesh.Shakti Energy Website of Bangladesh.Accessed 15 February,200 http //shaktiybpermart.net/articles/re/wahidul1.PDF

Islam,Mazharul. 2002.Assessment of Renewable Energy Resources of Bangladesh.Shakti Energy Website of Bangladesh.Accessed February 12,200 ttp //shaktiybpermart.net/publications/ebook1.pdf .h

Islam,Mazharul. 2002.Utilization of Renewable Energies in Bangladesh.Shakti Energy Website of Bangladesh. Accessed February 12,200 ttp //shaktiybpermart.net/publications/ebook2.pdf

Local Government Engineering Department (LGED). 2003.Project Implementation Plan for Sustainable Rural Energy,SE P Component 226.

National Implementation Committee (NIC). 2002.Renewable Energy in Bangladesh Present Status and Future Scenario. National Workshop on Promotion of Renewable Energy,Energy Efficiency and Greenhouse Gas Abatement (PREGA), arch 28,2002.

World Bank. 1 8. arket Assessment Survey of Solar PV Application in Bangladesh,Final Report. Dhaka,Bangladesh.

Annex 2-1: Status of R&D activities in Bangladesh

Technology	Organization	Remarks
Solar Photovoltaic/ Balance of System	Grameen Shakti, C ES,IFRD,BUET	Possible to manufacture all the balance of system components (like charge controller,cable,inverter, converter etc.) locally.
Solar Water Heaters	RERC,Dhaka University,IFRD, C E S	Possible to manufacture with local design and fabrication facilities.
Improved Stoves	IFRD	A number of designs have been developed at IFRD with three basic categories (I)improved stove without chimney (II)improved stove with chimney and (III)improved stove with waste heat utilization.
Solar Cooker-Parabolic	IFRD,ANANDO	IFRD has successfully field-tested its design which can quickly raise water to boiling point under clear sunny days. ANANDO is also manufacturing and marketing its products with imported materials and design.
Solar Cooker-Box Type	IFRD, C E S	IFRD's design is made of locally available raw materials. The manufacturing cost of such a cooker is about Tk.800 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.
Briquette achine	BIT hulna,BRRI	Under the RET in Asia Program,BIT hulna is developing better machines with longer screw life.
Biogas	IFRD, LGED, BAU	Fixed-Dome type plants are indigenously designed and constructed.
Water Current Turbine	Department of echanical Engineering (D E),BUET	D E,BUET are studying a model water current turbine for harnessing energy from river current and is in the process of developing a prototype.
Wind Turbines	BUET	Computational models are developed for simulation of horizontal and vertical axis wind turbines.

Source Islam, azharul,August 2002.Utilization of Renewable Energies in Bangladesh.Shakti Energy Website of Bangladesh. Accessed February 12,200 ttp //shaktiypermart.net/publications/#book2.pdf

Annex 2-2: Abbreviations

ANANDO	NGO for national development organization
BAU	Bangladesh Agricultural University
BCSIR	Bangladesh Council of Scientific and Industrial Research
BFRI	Bangladesh Forest Research Institute
BIT	Bangladesh Institute of Technology
BPDB	Bangladesh Power Development Board
BRRI	Bangladesh Rice Research Institute
BUET	Bangladesh University of Engineering and Technology
CHT	Chittagong Hill Tracts
CMES	Center for ass Education in Science
GoB	Government of Bangladesh
IFRD	Institute of Fuel Research and Development
LGED	Local Governance Engineering Department
PV	Photovoltaics
REIN	Renewable Energy Information Network
RERC	Renewable Energy Research Center
RETs	Renewable Energy Technologies
SEMP	Sustainable Environment anagement Programme
SME	Small and edium Enterprises
SHS	Solar Home System
SRE	Sustainable Rural Energy
UNDP	United Nations Development Programme
UP	Union Parishad