

**Bangladesh**

**Renewable Energy Report**



**APCTT-UNESCAP**

**Asian and Pacific Centre for Transfer of Technology  
Of the United Nations – Economic and Social  
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# Chapter One

## Brief overview of the country



Figure 1: Map of Bangladesh

### 1.1 Geography

Bangladesh lies between  $20^{\circ}34'$  and  $26^{\circ}38'$  North Latitude and  $88^{\circ}01'$  and  $92^{\circ}41'$  East Longitude with a total landmass of 1,47,570 square kilometers (56,977 Sq. miles). Bangladesh is surrounded by India on the West, North and Northeast, Myanmar on the Southeast and the Bay of Bengal on the South. Bangladesh has a strategic location and acts as bridge between South Asia and Southeast Asia.

### 1.2 Population

The Bangladesh Bureau of Statistics conducted a population census survey in the country on January 23 to 27, 2001. The population of the country stood at 124.35 million in 2001. The percentage of urban population was 23.52 while that of rural 76.47. Assuming medium variant of declining fertility and mortality the country is expected to reach a population of 145.46 million by 2011 A.D (Statistical Yearbook of Bangladesh 2008, BBS)

### 1.3 Climate

Bangladesh has a tropical monsoon climate with heavy summer rain and high summer temperatures. Winters are dry and cool. Main seasons prevail in Bangladesh are summer (March-May), Rainy Season (June-September) and winter (December-February). South and Southwest winds dominate from mid-April to mid-October and bring enormous amounts of moisture from the Indian Ocean and the Bay of Bengal. 95% of the total rainfall, which averages about 1733 millimeters, occurs during

that period. The temperatures range from an average of about 68 F (18C) in January to about 86 F (30C) in April. Climatic variations (average) over the year are given below.

Table 1: Climatic variations over the year

Season	Temperature		Rainfall	Relative Humidity
	maximum	minimum		
Pre Monsoon	32.6°C	22.4°C	453 mm	74%
Monsoon	31.5°C	25.5°C	1733 mm	86%
Post Monsoon	30.5°C	21.4°C	210 mm	80%
Winter	26.5°C	13.9°C	44 mm	73%
Annual	30.4°C	21.2°C	203 mm	78%

## 1.4 Economy

Bangladesh has an agrarian economy, although the share of agriculture to GDP has been decreasing over the last few years. Yet it dominates the economy accommodating major rural labor force. From marketing point of view, Bangladesh has been following a mixed economy that operates on free market principles.

Principal Seasonal crops and fruits: Paddy, Jute, Wheat, Tobacco, Pulses, Oil seeds, Spices, Vegetables, Jack-fruit, Banana Mango, Coconut

Principal Industries: Readymade garments, Textiles, Chemical fertilizers, Pharmaceuticals, Tea processing, Paper & newsprint, Cement, Light engineering, Sugar, Leather goods

Principal Minerals: Natural gas, Coal, Lime, White clay, Silica sand

Principal Exports: Readymade garments & knitwear, frozen fish, Jute & jute goods, Pharmaceutical products, Tea, Leather products, Handicrafts, Chemicals

## Chapter Two

### Conventional energy and Resources

#### 2.1 Electrical Energy

##### 2.1.4 Installed Capacity

In FY 2007-08, the total installed generation capacity of Bangladesh Power Development Board (BPDB) was 5202 MW including 1330 MW in Independent Power Producers (IPP) and 58 MW in Rental Power Plant. The installed capacity mix including IPP is shown below.

Table 1: Installed capacity of power

By type of plant		By type of fuel	
Hydro	230MW (4.42%)	Gas	4251 MW (81.72%)
Steam Turbine	2638 MW (50.72%)	Furnace Oil	280 MW (5.38%)
Gas Turbine	897 MW (17.24%)	Diesel	191 MW (3.67%)
Combined Cycle	1206 MW (23.18%)	Hydro	230 MW (4.42%)
Diesel	231 MW (4.44%)	Coal	250 MW (4.81%)
Total	5202 MW (100%)	Total	5202 MW (100%)

##### 2.1.5 Generation

In FY 2008, the maximum available generation of BPDB was only 4130 MW. The reasons for lower availability were 1) some plants were out of operation for maintenance, rehabilitation & overhauling, 2) capacity of some plants were derated due to aging, 3) gas shortage and 4) due to lack of rainfall in Kaptai lake, sending the rule curve (80 feet above mean sea level (msl) instead of 90 feet msl, standard for this time of the year) to a historic low. The net generation by BPDB and IPPs was 24311.15 GWh (BPDB 15173.45 GWh, IPP 9137.70 GWh). The net overall thermal efficiency of the generators in the public sector in FY 2008 was 31.81%.

In the East zone electricity generation was mainly by indigenous gas based power plants and a small percentage from hydro power plant. In the West zone, imported liquid fuel, domestic coal and natural gas were used for generation of electricity. Low cost electricity generated in the East zone, was also transferred to the West zone. The net generation by type of fuel is shown below.

Table 2: Generation capacity of power

By type of fuel	
Gas	20968.23 GWh (86.25%)
Furnace Oil	1090.86 GWh (4.49%)
Diesel	264.32 GWh (1.08%)
Hydro	949.62 GWh (3.91%)
Coal	1038.12 GWh (4.27%)
Total	24311.15 GWh (100%)

Under Private Sector power generation policy and guidelines in 1996 and 1998 small industries are generating their electrical power. The captive power generation is around 1800MW.

The Rural Electrification Board (REB) is charged with the responsibility to provide financial support, technical oversight, and long-term direction to the rural electrification program in Bangladesh. REB consumes about 32.26% power of BPDB. In the aim of alleviating the power shortage problem of the country, the Ministry of Energy, decided to go for Small scale power generation on Build Own Operate (B.O.O.) basis under the auspices. Up to June2008 REB had 105 MW power plants with net production of 70.87 GWh/year. REB is purchasing maximum 14 MW and minimum 6 MW or in average 10 MW captive powers.

### 2.1.6 Demand and Deficiency

The forecast demand was 5569 MW as per updated Power System Master Plan (PSMP-2006). Due to shortage of available generation capacity with respect to BPDB had to resort to load shedding, which varied up to 32.57% of the maximum demand. In FY 2008 load shedding was imposed on 358 days. During the year the total duration of grid failure was for 82 hours and five minutes.

Currently only 44 percent of the total population has access to electricity and per capita generation is only 174 kWh (Bangladesh Economic Review 2008). According to 2006-2007 report per capita electricity generation and consumption are 168.08kWh and 149.97kWh respectively.

According to the National Energy Policy the projected demand in 2005 of 5,720 MW will increase gradually to 11,794 MW by 2020 for low economic growth of 6% and for a higher growth rate of around 8% it should be 17580 MW.

## 2.2 Biomass Energy

The major part of energy consumed comes from biomass which is used mostly for cooking in rural areas and for rural industries. It forms 68% of total energy supply while 32% is supplied by commercial energy (including hydro power). At present 12 million tons of coal equivalent biomass is consumed in the industrial and domestic sectors along with commercial energy. Fire wood forms only 10% of the supply as shown below.

Table 3: Estimates of Energy Supplied by Traditional Biomass Fuels

(‘000’ tons of coal equivalent)

Fuels	2003-04
Cow-dung	2502
Jute stick	922
Rice straw	1218
Rice hulls	2854

Bagasse	392
Fire wood	1272
Twigs and Leaves	1537
Other wastes	1361
Total	12258

Source: BBS (Bangladesh Bureau of Statistics)

The consumption of biomass has remained stagnant over the years and there is little chance to produce a larger amount of biomass. However efficient biomass technologies can improve energy supply from biomass.

## 2.3 Fossil Fuels

### 2.3.1 Gas

The first commercial gas discovery was made in Haripur in 1955. Ever since then, exploration efforts have resulted in discovery of 23 gas fields of which 16 are currently in production, 4 are non-producing and 2 are suspended as partially depleted. Most of the initial discoveries took place in the late fifties and early sixties when the Rashidpur, Kailashitila and Habiganj gas fields were discovered by Shell during 1960-1963. At a smaller scale, a second spurt of discovery took place in the late nineties, Bibiyana with proven reserve of 2.5tcf gas being the most important. The latest discovery of gas took place in May 2006 with small discovery of 0.44 tcf of gas at Barguna. There has been no major gas exploration effort since 1998 and no major discovery of gas also happened thereafter.

According to the Gas Initially in Place (GIIP) data, Bangladesh has 21.3 tcf of proven gas (P1; proved or with probably of 90 percent of greater or equal volume). Out of which 15.4 tcf is recoverable and 7.7 tcf of gas has already been produced. Another 7.7 tcf gas is proven remaining. In addition, there is 5.5 tcf of gas as probable recoverable (P2; probable or with probability of 50 percent exceeding) reserves. There is also 7.7 tcf of gas possible recoverable (P3; possible or with probability of 10 percent exceeding) reserves. Titas, Hobiganj, Kailastila, Rashidpur, Bakhrabad, Jalalabad and Sangu are the major gas fields of Bangladesh (Gas Reserve of Bangladesh (as of June 2008), Petrobangla). Country's gas production reached the highest ever 1900 million cubic feet per day (mmcf/d) on 04.04.2009 riding on mounting output of onshore gas supplies especially by the international oil companies (IOCs).

On the consumption side, the leading consumer is the power sector (42%). Consumption of the sector would be higher if one includes gas consumed in captive power generation (11%). The power sector is followed by fertilizer (15%), Industries (13%), Domestic consumers (10%) and CNG (5%). Other minor consumer categories include Commercial (1%) and Tea sector (0.22%).

Table 4: Production and Consumption of Natural Gas

(Qty in million cubic metre)

Category/Year	2007-08
Gas Production	17014.5
Consumption: (10 <sup>9</sup> cft)	16554
Electricity	6634
Fertilizer	2228
Industrial	2611
Commercial	187
Domestic	1906
Others	2988

Source: Petrobangla

### 2.3.2 Coal

The total coal reserve in 5 coal fields of Bangladesh is estimated to be 2.9 billion metric tons (table given below). This is energy equivalent to 67 tcf of gas. Recovery rate of coal from reserves varies with the choice of technology and method of mining. Assuming a modest recovery rate of 30 percent coal, the available reserve will translate to about 20 tcf of natural gas equivalent.

Table 5: Coal Reserves in Bangladesh

No.	Place/Field (Discovery)	Depth (Meter)	Area (Sq. Km.)	Proven Reserve (Million Ton)
1	Barapukuria, Dinajpur (1985)	119-506	6.68	390
2.	Kailashpur, Rangpur (1995)	257-483	12.00	143 (GSB), 685 (Hosaf)
3.	Phulbari, Dinajpur (1997)	150-240	30.00	572
4.	Jamalganj, Jaipurhat (1965)	900-1000	16.00	1050
5.	Dighirpar, Dinajpur (1995)	327	Yet to be known	200 (Partly evaluated)

Sourcc: Petrobangla

The discovered fields differ in respect of depth ranging between 119-506 meters and 150-240 meters in Barapukuria and Phulbari respectively. The depth of the coal field discovered in Jamalganj is 900-100 meters. The area covered by coal fields are rather limited and is about 70-80 square kilometer area.

Out of the five coal fields discovered in Bangladesh, production is ongoing at Barapukuria Coal Mines only. A total of 1.73 million metric tons of coal has been extracted from the mine till December 2008. Coal mining at Phulbari and other coal fields now hinges on the Coal Policy under consideration of the government. Approval of the Coal Policy is pending for quite some time due to disagreements on two main issues, namely, (a) open pit versus share mining and (b) compensation and rehabilitation of affected families.

### 2.3.3 Petroleum Products

Petroleum products constitute about 23 percent of the commercial energy used in the country. Bangladesh has insignificant domestic production of petroleum products. Petroleum products are imported by Bangladesh Petroleum Corporation (BPC), the designated authority for the purpose. Bangladesh imports about 1.2 million tons of crude and 2.5 million tons of refined oil each year. Total imports, including lubricants, vary from 3.2 to 3.7 million metric tons per annum. Following table shows the quantity and value of imported petroleum products from FY 2007-08 to 2008-2009.

Table 6: Imports of petroleum products

FY	Crude		Refined		Lube Oil		Total	
	Qty	Value	Qty	Value	Qty	Value	Qty	Value
2007-08	1140	566	2136	16821	9	51	3285	22532
'08-09	386	2172	1427	7467	0	0	1813	9639

(Up to Feb  
'09

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Source: Bangladesh Petroleum Corporation

Bangladesh transport system depends almost totally on imported liquid fuels. Kerosene is used widely for lighting in villages while diesel generators are getting unavoidable while the cost of import is soaring high and becoming prohibitive.

## 2.4 Tentative future combination of energy in power production

Natural gas reserves in Bangladesh are likely to be depleted before 2020 and electricity production from gas may go stop. Coal may supply 250 MW from Barapukuria deposits. As the demands would be over 11000 MW serious attempts have to be made for energy conservation and for high efficiency along with explorations for gas and coal reserves to avert an impending disaster from shortage of energy supply. Government has declared to generate electricity from renting power systems and coal-fired systems. But more importantly energy supplies using RETs must be developed and utilized.

To meet the demand of 2020, additional power production should be made from the following sources-

Table 7: Tentative combination of energy in 2020

For 6% economic growth		For 8% economic growth	
Conventional sources:	3000MW	Conventional sources:	6000MW
Atomic sources:	1000MW	Atomic sources:	2000MW
Renewable sources:	2000MW	Renewable sources:	4000MW

## Chapter Three

### Assessments of renewable energy resources

Despite all possible attempts by Bangladesh Power Development Board (BPDB), Rural Electrification Board (REB), electrification via the grid of a greater percentage of the households will remain a difficult task in the near future. These difficulties are due to a number of factors such as: remoteness; isolated and scattered location of the rural households; inadequate load demand; lack of financial viability and resource constrains for building infrastructure. The costs of reaching grid electricity to these areas are prohibitively high and cannot be made affordable in the near future.

#### 3.4 Solar Energy Resource Assessment

Recently an assessment of solar energy resource over the country was conducted by Renewable Energy Research Centre (RERC), University of Dhaka. The project was aided by United Nations Environment Program (UNEP) and Global Environment Facility (GEF). In the program RERC collected ground solar radiation data at RERC and seven other Bangladesh Meteorological Department locations. The ground data were used along with 40 km resolution map developed using CSR (Climatological Solar Radiation) model by National Renewable Energy Laboratory, USA and 10 km resolution map developed using a satellite image by German Aerospace Center (DLR), Germany.

Monthly averaged global horizontal irradiances from January 2003 to December 2005 are given below.

Table 1: Monthly averaged hourly GHI (Wh/m<sup>2</sup>)

Hours/month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
<b>5:30</b>			1	5	17	19	11	7	3			
<b>6:30</b>	3	8	29	66	106	93	86	66	58	46	31	11
<b>7:30</b>	57	93	148	198	252	200	198	180	165	169	157	97
<b>8:30</b>	175	254	318	354	406	321	355	288	303	324	331	237
<b>9:30</b>	300	424	489	521	561	416	438	433	435	473	490	382
<b>10:30</b>	411	573	629	666	681	494	503	514	485	487	580	479
<b>11:30</b>	494	672	712	751	727	532	548	537	485	520	614	498
<b>12:30</b>	518	701	722	764	711	543	570	535	486	488	573	489
<b>13:30</b>	483	646	657	693	641	500	503	482	441	406	510	426
<b>14:30</b>	379	528	541	553	577	451	463	453	385	323	377	309
<b>15:30</b>	236	353	377	402	419	329	372	356	281	208	204	183
<b>16:30</b>	94	175	204	237	257	215	244	231	164	76	57	54
<b>17:30</b>	10	37	55	72	93	93	107	89	45	6	1	2
<b>18:30</b>			2	4	11	17	18	8	1			
<b>Daily average (kWh/m<sup>2</sup>-day)</b>	3.16	4.46	4.88	5.28	5.46	4.22	4.42	4.18	3.74	3.53	3.92	3.17

Note: 5:30 represents the period between 5am to 6am

To estimate radiation values over Bangladesh sunshine duration and cloud cover measured by Bangladesh Meteorological Department at 31 stations are used employing correlations developed at RERC. Mean annual values of Global Horizontal Insolation obtained is shown below.

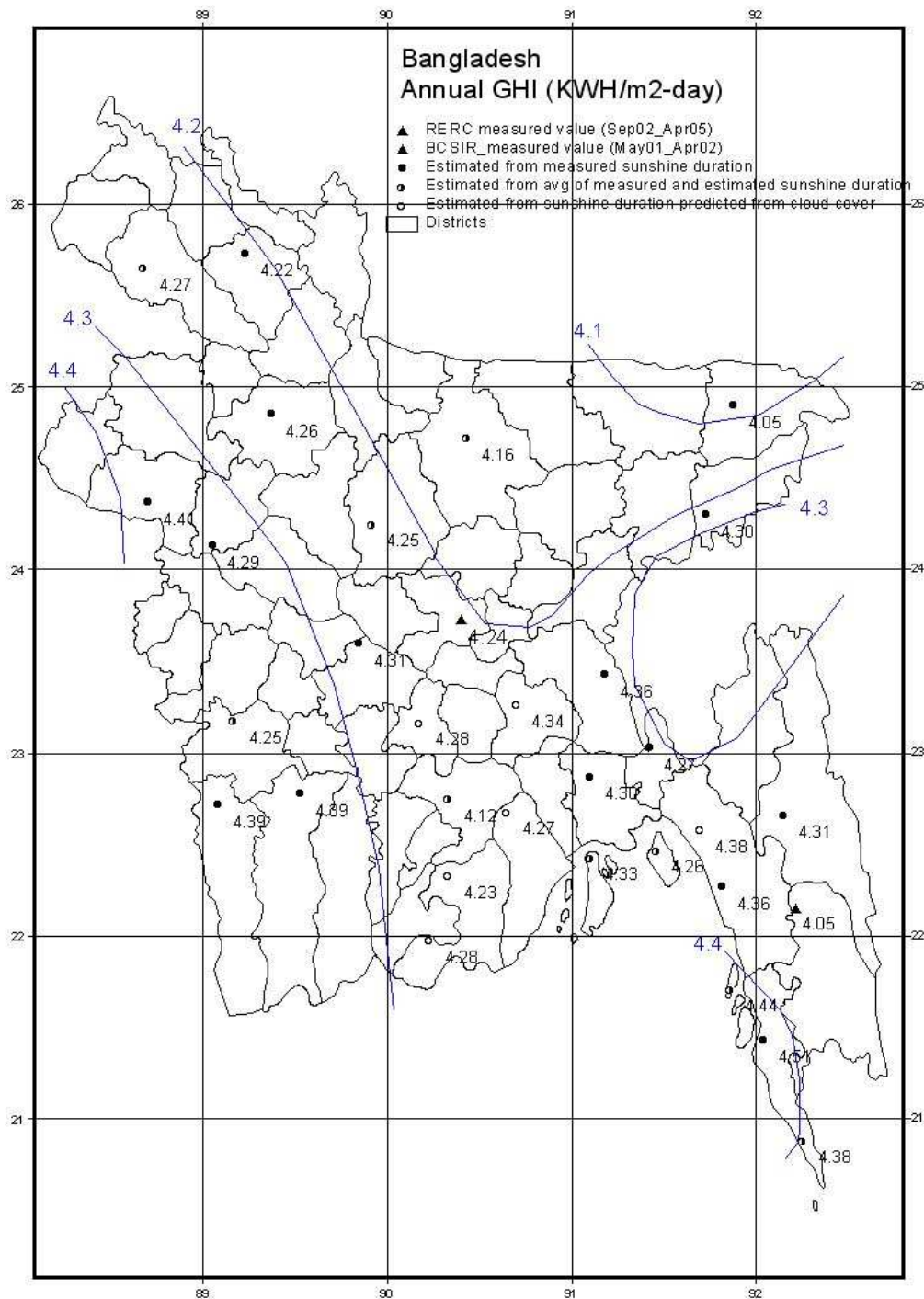


Fig. 1: Annual values of Global Horizontal Insolation for 31 locations in Bangladesh



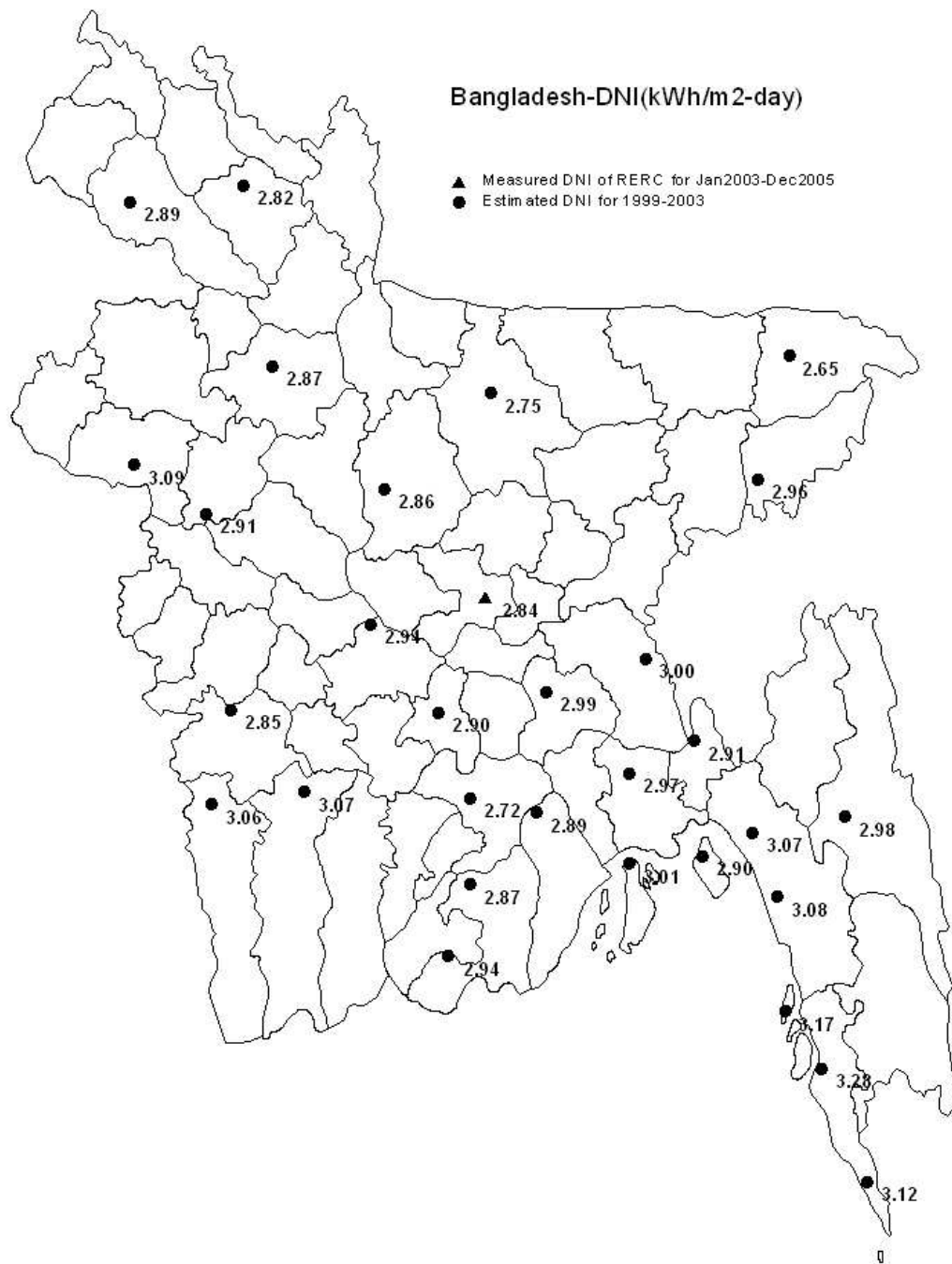


Figure 18: Annual Measured and Estimated DNI for RERC and BMD stations

The final map of global horizontal irradiance, based on the measured data, theoretical model derived data and satellite image derived data shows that monthly average solar global radiation in Bangladesh is around 4.255kWh/m<sup>2</sup>/day and wind speed at the coastal area is around 4.5m/s (Final report February 2007). The output maps of the research project are given below.

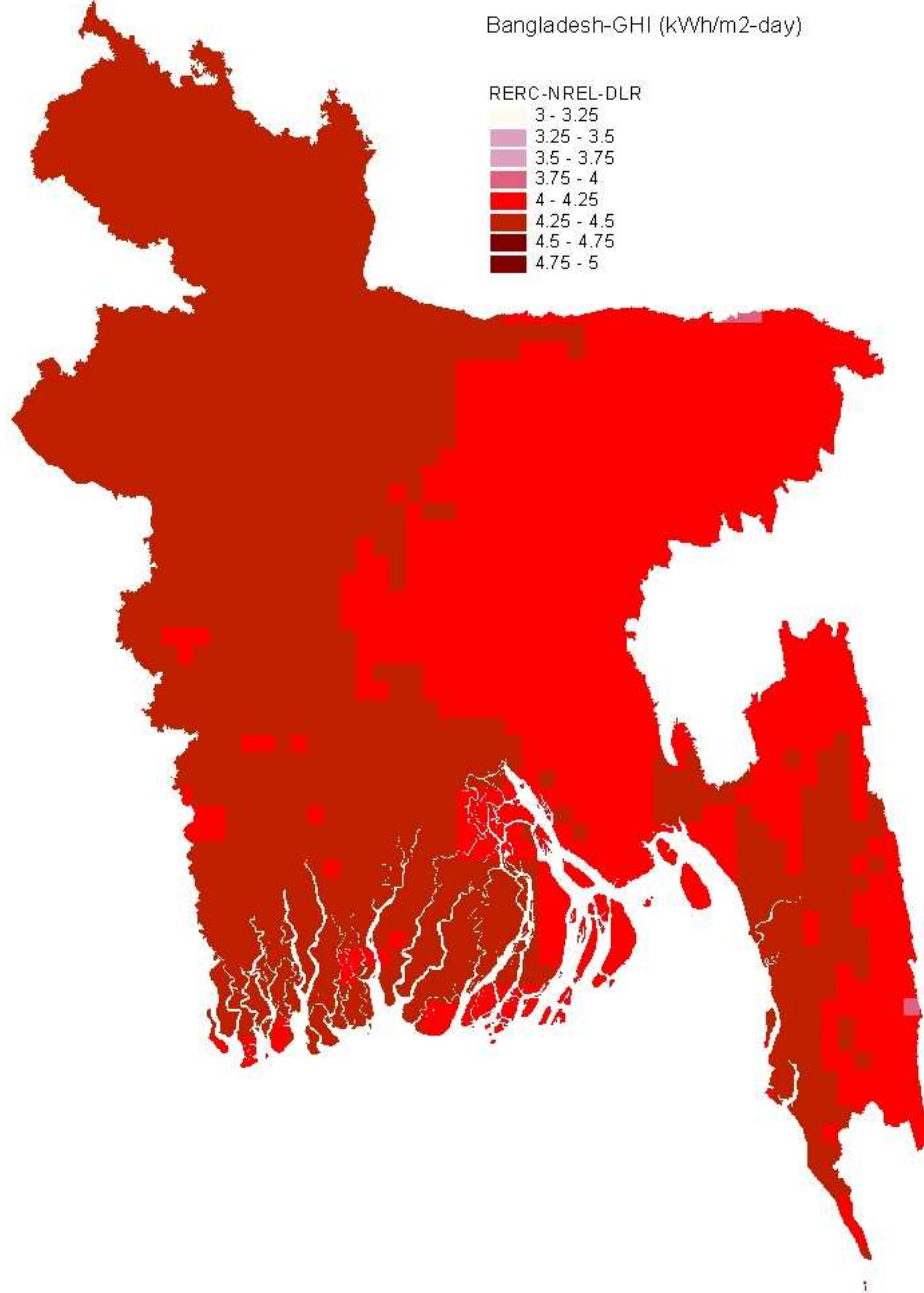


Fig 2: Global Horizontal Irradiance map of Renewable Energy Research Centre (RERC)-National Renewable Energy Laboratory (NREL) - *German Aerospace Center (DLR)* showing averaged NREL and DLR maps tuned to Dhaka

Annual diffuse radiation map of NREL tuned to Dhaka is given below.

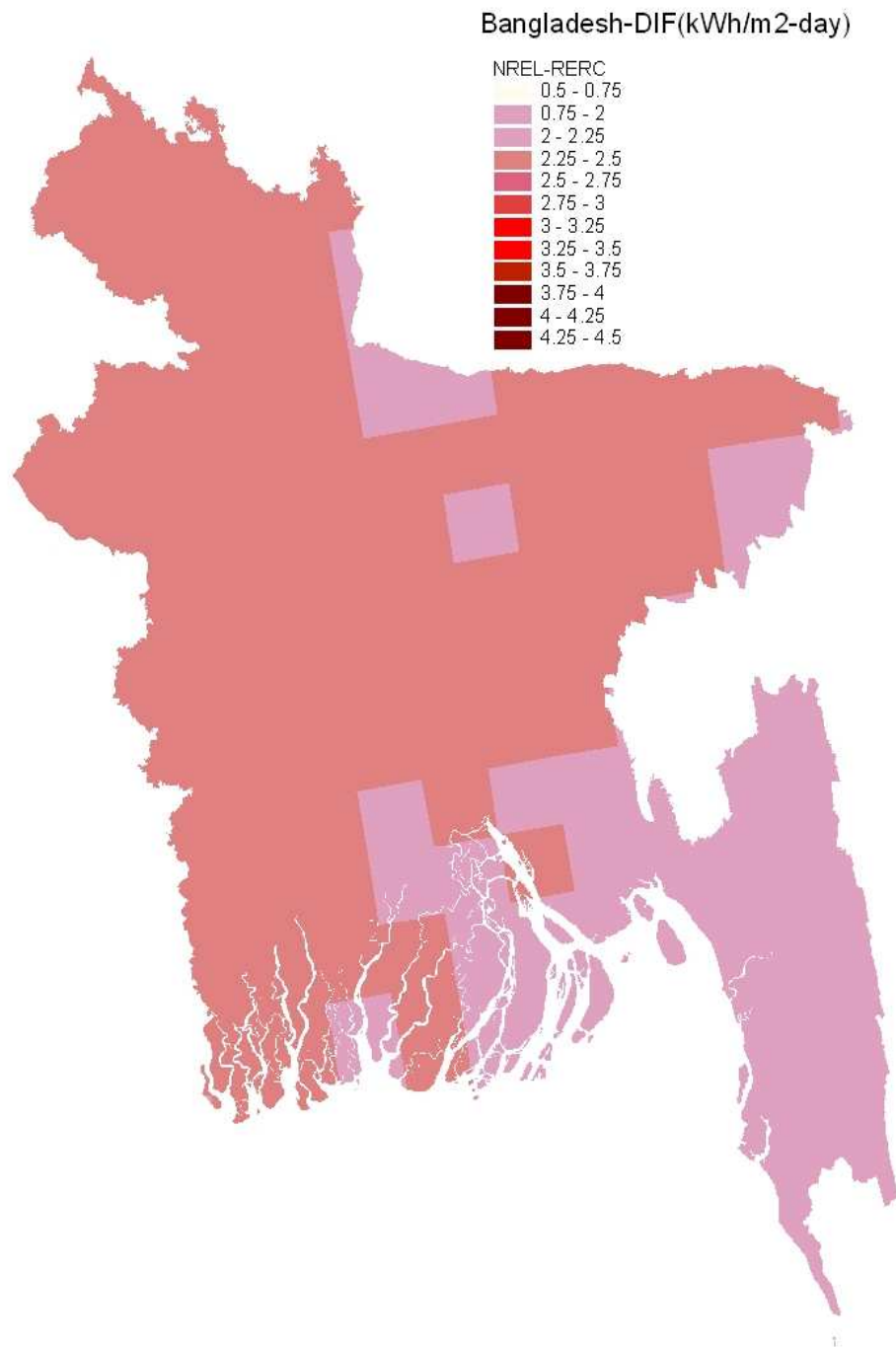


Figure 3: Annual DIF map of NREL tuned to Dhaka

### 3.5 Wind Energy Resource Assessment

In Bangladesh, adequate information on the wind speed over the country and particularly on wind speeds at hub heights of wind machines is not available. A previous study (1986) showed that for the wind monitoring stations of Bangladesh Meteorological Department (BMD) the wind speed is found to be low near the ground level at heights of around 10 meter. Chittagong – Cox’s Bazar seacoast and coastal off-shore islands appeared to have better wind speeds. Measurements at 20m and 30m heights have been made later on by BCAS, GTZ and BCSIR. WERM project of LGED for measurements at the height of 20 and 30m have been going on for 20 locations all over Bangladesh.

However, the speed at a higher height of 50m which is often used for wind generators has not been available. This SWERA Program provides predictions for wind speed and wind energy density at different heights including 50m height to look for the possibility of wind power generation. For prediction of wind speed at different heights and for assessment of wind energy in the coastal part of Bangladesh, Wind Atlas Analysis and Application Program (WAsP), a micro-scale modeling software has been used. WAsP develops models for obstacles, roughness and terrain surrounding a measuring station and then generates a regional wind climate or a wind atlas for the region around 100km<sup>2</sup> in area.

Wind resource assessment over Bangladesh has been done independently by RISOE National Laboratory, Denmark using KAMM (Karlsruhe Atmospheric Meso-scale) model. The model uses upper atmosphere wind speed data and satellite information. Based on a comparison between KAMM (done by RISOE) and WAsP results (done by RERC) the wind resource map for Bangladesh has been developed. The maps are given at the following pages.

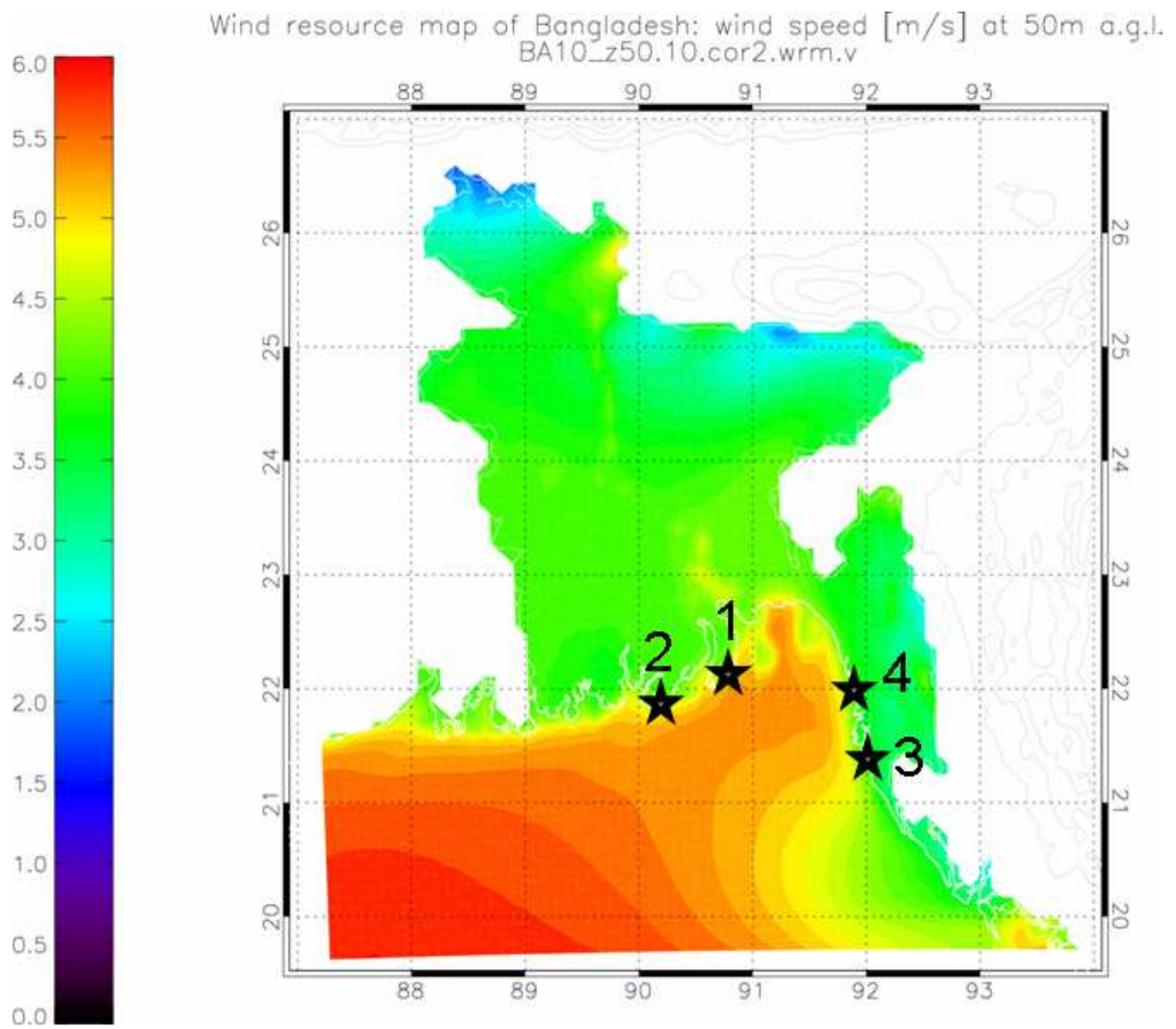


Figure 4: Annual mean simulated wind speed at 50 m a.g.l.

Wind resource map of Bangladesh: wind speed [m/s] at 50m a.g.l.  
BA10\_z50.10.cor2.wrm.e

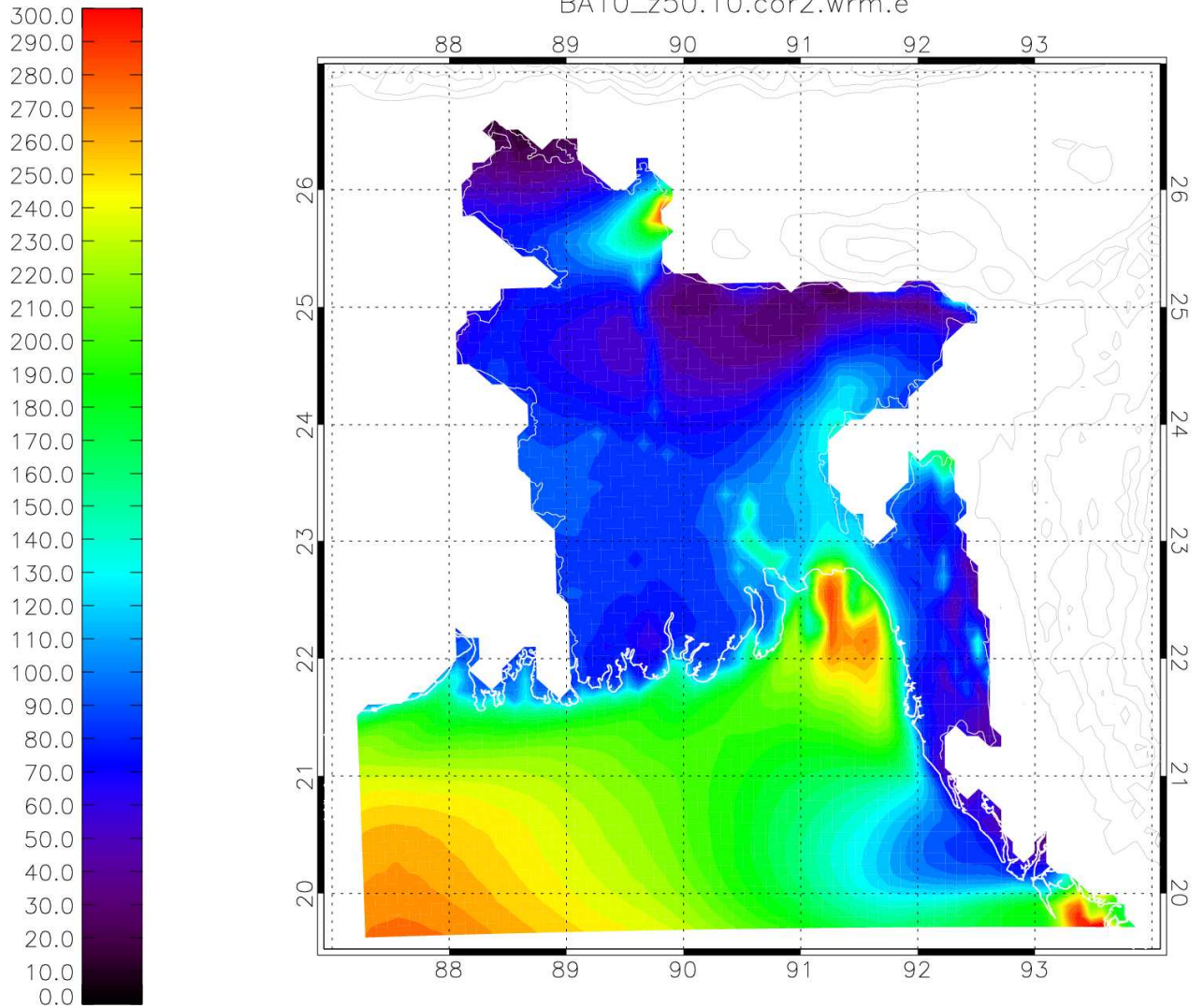


Figure 5: Annual mean simulated wind power density at 50 m a.g.l.

**3.6 RET(s) that are best suited to the country's climatic conditions**

Based on the solar and wind resources over the country one can comment that most of the solar energy extracting systems can be used over the country. For wind energy use the area is limited mostly at the coastal areas. The diffuse component of solar radiation is around 50% and non-concentrating PV or thermal collectors should be most suitable for use.

For biogas generation cowdung is available and hence the system is suitable for the country. Studies were done to make electricity from the municipal waste but didn't show feasible as the dumped components are not sorted.

For geothermal energy extraction the resource site is almost zero. For biomass energy use briquetting technologies are suitable in Bangladesh as resources are available. Studies on tidal energy are going on.

The RETs that are well suited to the country's climatic conditions are

- Solar Lantern (mostly LED based)
- Solar Home System/ Solar Stand alone systems
- Grid connected photovoltaic systems
- Solar water pumping for irrigation
- Solar Water Heaters
- Solar Dryers
- Solar cookers
- Water lifting wind turbine
- Wind electricity generators
- Grid connected wind turbine
- Micro hydro generator
- Biogas plants
- Electricity production from rice husk
- Electricity production from poultry waste
- Briquetting technology
- Mini grid for village electrification etc

## Chapter Four

### Potential of different RETs

A small amount of coal, around 0.1 million ton, is imported annually. Natural gas reserves in Bangladesh are likely to be depleted before 2020 and electricity production from gas may stop. As the demands would be over 11000MW serious attempts have to be made for energy conservation and for high energy efficiency along with explorations for gas and coal reserves to avert an impending disaster from shortage of energy supply. But more importantly energy supplies using RETs must be developed and utilized. A brief overview of some RETs is given below.

#### 4.1 Solar Lantern

Least cost LED based lanterns can be made of 5W power capacity. The target group of solar LED based lantern is the dwelling households whose residents are poor or residing below the poverty lines. About 40% of the population has the status of below poverty line.

Population Census 2001, BBS shows that there is total of 25491000 households in Bangladesh (Urban 6035000, Rural 19456000). For 25034000 dwelling units the potential solar LED based lantern is 10.0 million.

#### 4.2 Solar Home System

As per the report of Sample Vital Registration System (SVRS)-2007 the electricity connections in urban area is 86.25% and in rural area it is 38.73%. So the 61.26% households in rural (of 19306000) and 13.74% households in urban (of 5728000) is the potential user of solar home systems. On an average a family has 2 households and generally prefers 30W solar home systems. Hence the potential of SHS is about 12 million.

Solar home systems generally supply electricity at night time for 4 to 5 hours only from battery backup. Hence these wouldn't be popular in areas where electricity is available. In experience it can be found that in rural areas where electricity is available, they are deprived of smooth electricity. For few hours they can get electricity infect. Hence the rural households where electricity is not available and as well as where it is available can be the potential customers. The potential number of consumers would increase from 1.2 million.

If 1% area of Bangladesh is covered by 10% efficient solar panels electricity generation would be 40000MW.

#### 4.3 Mini grids

Village-scale mini-grids can serve tens or hundreds of households. Traditionally, mini-grids in remote areas and on islands have been powered by diesel generators or small hydro. Generation from solar PV, wind, or biomass, often in hybrid combinations including batteries and/or a supplementary diesel generator, is slowly providing alternatives to the traditional model, mostly in Asia. Thousands of mini-grids, primarily based on small hydro exist in India, Nepal, Vietnam, and Sri Lanka. The use of wind and solar PV technologies in mini-grids and hybrid systems is still on the order of a thousand systems worldwide, mostly installed in China since 2000.

Total number of villages in Bangladesh is 87319. 70 Palli Bidyut Samittis operating under the supervision of the Rural Electrification Board have electrified 47308 villages (Rural Electrification Programme, as on February' 2009) in 61 districts. Therefore the rest 40011 villages can be electrified using microgrid or minigrid with renewable energy based power, either they are in island or in remote areas.

Table 1: Typical load profile of a family comprised of 3 households

Load	No. of load	Wattage/load	Hours/day	Days/week
Light	4	20	5	7
Fan	2	80	10	7
TV	1	60	3	7
Radio	1	10	3 (day & night)	7
Mob. Charger	1	10	5 (day)	2
CD player	1	80	2	5
Total load=				3kWh/day (considering inverter efficiency)

Say there are 300 families in a village. Then demand per village is 900kWh/day. If micro grid is used for all un-electrified villages (400011) then 30,000 MW can be installed over the country. If we consider another typical family with 4-light, 2-Fan, 1-Radio and 1-Mobile charger, then the required power will be 10,000 MW.

#### 4.4 Solar water pumping

In irrigation total demand is about 1260 MW but actually supply is about 760 MW. REB and PDB ensure minimum 8 hours electric supply during irrigation period.

According to REB (as of Feb 2009) 225205 electricity connections were given for irrigation. Most of these are for shallow and for low lift pumps. RET can replace the grid electricity for these pumps in a simple attempt of Gov. For deep tube wells of REB and PDB some R&D efforts should be taken before implementation.

Statistics of Bangladesh Petroleum Corporation for 2003-2004 shows 651073 MT petroleum products were sold in agricultural sector. This petroleum can be saved using RET.

#### 4.5 Grid connected PV system

Generally in Dhaka the available rooftops of multistoried buildings are of around 3000square feet. In this area easily 15kW solar modules can be placed at tilted position. Such buildings are roughly 20000 in number. Hence if these roofs are covered with solar modules 300MW power can be generated confidently. At other metropolitan cities and urban area a total of another 20000 buildings are available. Hence 300MW additional power can be generated.

#### 4.6 Solar Water Heating System

Bangladesh is a tropical country. Generally hot water is not required in daily life. But this solar water heating system can be used as for low temperature water heating or as a pre heater in institutions. Studies on locally developed selective coatings and overall system show that this system can be used

throughout the year. Hence primary potential areas of flat plate solar water heating system would be the handloom industries, hotels/motels and hospitals/clinics in Bangladesh. Assessment of SWHS potentials have been described below.

a. In Handloom industries

In Bangladesh 183512 units of handloom industries exist. In these industries 505556 looms had been set up. Out of these looms 311851 looms are operational. From the operational looms 38944 looms are in urban areas and 466612 looms are in rural areas. (Source: Handloom Census 2003). For each loom 6 square meter collector area is required to heat 170 litre of water from room temperature to 80°C over the year. Urban establishments may use gas, hence if only the rural establishments are considered, the total potential of collector area is 2800 thousand square meter. Considering 30 sqm for 1000 liter system, about 93 thousand systems can be installed.

b. In Medical Sector

The health infrastructure of the country has been built on the country's general administrative pattern, which follows the national government, divisional administration, district administration, upazila (sub-district) administration, union administration, and ward administration. There are 431 upazila level hospitals with total beds of 14579. Hospital statistics shows that in upazila health complexes bed occupancy rate was 73%. Studies show that for a 50 bed medical with occupancy rate of 75% needs 115 square meter collector to heat 7382 liter of water from room temperature to 70°C daily. Hence for 14579 beds 34 thousand square meter collector can be utilized. The total number of systems will be 1.14 thousand.

On average bed occupancy rate of urban hospitals is more than 100%. For urban hospitals of 20590 beds around 48 thousand square meter collector should be installed. In this case the total number of systems will be 1.6 thousand.

c. In Hotels

13 Govt Tourist hotels and motels have a total of around 750 beds. A study like solar water heater for hospitals shows a potential of collector area of around 2 thousand square meter. There are a large number of private hotels. So, many systems can also be installed in the hotel sector.

#### **4.7 Solar cooker, Improved biomass cooker and rice husk gasifier**

The contribution of biomass energy is two thirds of the total energy consumption in Bangladesh. Biomass energy is mainly used for cooking and par-boiling by rural households and by small rural industries such as rice mills and sugar industries. In order to meet the growing energy demand, forest resources are being depleted at an alarming rate. It must be noted that the introduction of high yielding varieties of rice crops has also reduced biomass production. By virtue of Bangladesh's geographical location, the use of solar energy for household lighting and other sectors are emerging.

Population Census, 2001, Preliminary Report (provisional) shows that there are total 25307600 households in Bangladesh where in rural and urban areas the number is 20255957. About 67% of rural household obtained firewood from own source whereas in urban areas 87.9% of households bought firewood from others (Bangladesh Population Census 1991, Volume 4 Socio-economic and demographic report, published 1999). The number of landless is increasing. Hence in rural area the above 60% people may now be 50%. Therefore about 10 million solar cooker or improved biomass cooker can be installed in rural areas. In municipality or urban areas the potential of improved cooker or solar cooker is not high.

Biomass gasification is viewed today as an alternative to conventional fuel. Biomass gasification is the process of converting solid fuels (rice husk, wood/ wood-waste, agricultural residues etc.) into a combustible gas mixture usually called the “Producer Gas” i.e. biomass materials are gasified to produce “Producer Gas”. The technology can be used for both thermal applications and power generation. About 40 - 45,000,000 metric tons (MT) of Paddy is annually produced in the country. Taking a 20% yield of husk, based on input paddy, this leads to a production of 8 - 9,000,000 metric tons of Rice Husk annually. Using the Biomass Gasifier Technology and considering that about half of the husk is used for energy applications such as domestic cooking, steam production for rice parboiling etc., the Theoretical Potential ( $E_{THEOR}$ ) is about half of the remaining husk i.e. 4 million MT / Yr. of husk, is estimated at a little over about 400 MW of capacity, taking about 16-hr/day x 300 days of typical Rice Mill operation, if a gross specific consumption of about 2 kg of husk per kWh of electricity generated. The Technical Potential ( $E_{TECH}$ ), however, considering many practical factors, based on the size, number and the location of the rice mills, the estimate is indicative of about 100 MW which is the typical electric load requirement about 500 Rice Mills amongst a total national rice mill population of over 100,000, requiring an average electricity generation of about 200 kW (or 250 kVA) for each mill..

The Rice Mill Owners’ Association of Bangladesh reports over one hundred thousand rice mills which are located in a scattered manner all over the country with about four (4) ‘cluster’ area. Over ninety percent of these rice mills are reported to be in the smaller capacity ranges, i.e. < 20 - 25 MT/day of Paddy processing capacity. The number of lower-mid sized rice mills (with paddy processing capacity range : > 25 - 50 MT/day) are reported to be about 490 and that of mid to large sized rice mills (30- 120 MT/day) are about 50 units. As already mentioned, primarily, about five (5) distinct ‘cluster’ areas of rice mills are known in the country - (i) Dinajpur (North Bengal) (ii) Sherpur (near Bogra) (iii) Inshawerdi and (iv) Kaliakoir (near Dhaka), where most of the rice mills are located in a dense manner, i.e. in close proximity to each other. Hence, based preliminary surveys (ref.: Bangladesh Rice Research Institute, BRRRI and information from Rice Mill Owners’ Association), typically at least over 500 rice mills are located in these cluster areas. Taking an average (lower-mid) capacity range of about 100-200 kW, there is a 50-100 MW power market in these cluster areas.

#### **4.8 Wind electricity**

The developed wind atlas of four coastal locations of Bangladesh, Charfassan, Chittagong, Kutbdia and Cox’s Bazar using one year data of BCAS shows that at 50m height for the roughness value from 0m (open sea, water areas) to 0.03m (farm land with very few buildings, trees, airport areas etc) the wind speed varies from 4.1 to 5.8 m/s with a power density of 100 - 250 w/m<sup>2</sup>. Wind energy density predicted by RISOE show locations with power density above 200W/m<sup>2</sup> over 2000km<sup>2</sup> which is highly encouraging. If suitable turbines are placed in this area with hotspots, 2000 MW of electricity can be produced easily. 300 wind and diesel generator hybrid micro grids each of around 100kW can be placed in this area.

#### **4.9 Biogas plants**

Already a good number of biogas plants have been installed. About 0.202 million poultry farms are here where biogas plants can be readily installed. The number of families with 4 cows is 2.3 million, which are suitable for biogas plant implementation (Personal communication, Gofran, Grameen Shakti, 4 July, 2009)

#### **4.10 Micro hydro**

Hydropower is an eco-friendly clean power generation method. The scope of hydropower generation is very limited in Bangladesh because of its plain terrains except in some hilly region in the northeast and southeast parts of the country. However there are lots of canals, tributaries of main river Karnafuli, Shangu, Matamuhuri as well as tiny waterfalls having good potentials for setting up mini/micro hydropower unit in Chittagong Hill Tracts (CHT) region.

To explore potential sites of micro-hydro, several studies have been conducted by Bangladesh Water Development Board (BWDB) and BPDB in 1981. List of prospective sites is shown in the following tables.

Table 2: Potential Small Hydro Sites identified by BPDB and BWDB

<b>District</b>	<b>Name River/Chara/Stream</b>	<b>Potential of Electrical Energy in KW</b>
Chittagong	1. Foy's lake	4
Chittagong	2. Choto Kumira	15
Chittagong	3. Hinguli Chara	12
Chittagong Hill Tracts	4. Sealock	81
Chittagong	5. Lungichara	10
Chittagong	6. Budiachara	10
Sylhet	7. Nikhari Chara	26
Sylhet	8. Ranga pani Gung	616
Jamalpur	9. Bhugai-Kongsa at 2 miles U/S. of Nalitabari P.S	69Kw for 10 months 48 Kw for 2 months
Jamalpur	10. Marisi at Dukabad near Jhinaigati Thana Head Quarter	35Kw for 10 months 20 Kw for 2 months
Dinajpur	11. Dahuk at Burabari	24
	12. Chawai at U/S. of Chawai L.L.P	32
	13. Talam at U/S. of Talam L.L.P	24
	14. Pathraj at Fulbari	32
	15. Tangon at D/S of Nargun L.L.P	48
	16. Punarbhaba at Singraban	11
Rangpur	17. Buri Khora Chikli at Nizbari	32
	18. Fulkumar at Raiganj Bazar	48

In 2004 Sustainable Rural Energy, Local Government Engineering Department has explored some potential micro-hydro sites in CHT region which is listed in table

Table 3: Micro-Hydropower sites identified by SRE study in 2004

<b>Site</b>	<b>Expected Power Generation</b>
Nunchari Tholipara, Khagrachari	3 KW

Chang-oo-Para, Bandarban	30 KW
Bangchari, Bandarban	25 KW
Liragaon, Bandarban	20 KW
Kamalchar, Rangamati	20 KW
Thang Khrue, Rangamati	30 KW
Monjaipara, Bandarban	7.5 KW

#### 4.11 Summary of potential of RETs in Bangladesh

A summary table of the RETs potential is given below.

Table 4: Potential of RETs

RET	Unit size	Potential number	Total conventional unit
Solar LED based lantern	5W	11 million (below poverty line)	55 MW
Solar LED based lantern + 10W CFL	15W	11million (below poverty line)	165 MW
Solar Home System	30W	12 million	360 MW
Mini grids	12.5W	40011	30000 MW
Mini grid of moderate size			10000 MW
Solar water pumping		225000 (around)	1200 MW
Grid connected PV system			600 MW
Solar PV System		1% area of Bangladesh with 10% efficiency	40000 MW
Rice husk gasifier	200kW	500	100 MW
Wind electricity			1000 MW
Micro hydro			1.2 MW (according to BPDB)
Biogas power plants		0.202 million (from poultry waste)	Potential 400 MW Possible generation 100 MW

Table 5: Potential of RETs

RET	Unit size	Potential number	Total conventional unit
Solar Water Heating System (Handloom Industries)	1000 liter (up to 80°C)		93 thousand systems
Solar Water Heating System (Medical Sector)	1000 liter (up to 80°C)		1.1 thousand systems
Solar Water Heating System (Hotel Sector)	1000 liter (up to 80°C)		many systems
Solar cooker and improved biomass cooker	Standard household solar cooker	10 million	
Biogas plants		2.3 million (having 4 cattle or above)	35000 biogas plants installed, 15000 functioning

## Chapter Five

### Salient features of the government's policy on renewable energy

At present the official capacity of Bangladesh Power Development Board is around 5000MW, while it can practically generate less than 4000MW. The government has taken up various power projects which will bring around 5000MW power by 2014. The Government is giving its best effort to reach the goal of providing electricity service to all the people by the year 2020. Along with the reform program, Government has taken a number of time bound development plan. In view of the target the government has developed a number of policies on energy. The policies are-

- National Energy Policy (NEP) in 1996
- Private Sector Power Generation Policy in 1996
- Policy Guidelines for Small Power Plants in Private Sector in 1998
- Vision Statement and Policy Statement on Power Sector Reforms in June 2000
- Energy Regulatory Commission Act 2003
- Renewable Energy Policy, 2008
- Govt. Initiatives on RET, 2009

Salient features of the government's policy on Renewable Energy Policy are-

- Policy sets targets for developing renewable energy resources to meet five percent of the total power demand by 2015 and ten percent by 2020.
- Create enabling environment and legal support to encourage the use of renewable energy
- Promote development of local technology in the field of renewable energy
- An independent institution, Sustainable Energy Development Agency (SEDA), shall be established under the Companies Act. SEDA in conjunction with the Power Division of the Ministry of Power, Energy and Mineral Resources shall be responsible for determining the priorities for renewable energy technology development and program implementation. Power Division of the MPEMR or its assignee will facilitate the development of renewable energy until SEDA is formed. Overall policy formulation and development functions of renewable energy shall lie with the Power Division of the MPEMR.
- Implement policies for mitigation of environmental issues arising out of use of Renewable Energy
- Processing of grid connected renewable energy projects
- Provide fund for the development of standardized renewable energy configurations to meet common energy and power applications
- Electricity generated from renewable energy projects, both in public and private sectors may be purchased by power utilities or any consumer through mutual agreement (up to 5 MW).
- To promote renewable energy in power sector, all renewable energy equipments and related raw materials in producing renewable energy equipments will be exempted from charging 15% VAT. In the last budget of 2009-2010 the government has
  - Released VAT in solar panel import, local production and distribution
  - Reduced the tax on the solar panel from 3% to 0%.
  - Reduced the tax and VAT on import of energy saving lights from 7% to 0%

- Bangladesh Bank has sanctioned a revolving fund of 200Crore Tk. for renewable energy projects.
- In addition to commercial lending, a network of micro-credit support system will be established especially in rural and remote areas to provide financial support for purchases of renewable energy equipment.
- SEDA will consider providing subsidies to utilities for installation of solar, wind, biomass or any other renewable/clean energy projects.
- Private sector participation including joint venture initiatives in renewable energy development will be encouraged and promoted. Power division of MPEMR/SEDA may assist in locating the project(s) and also assist in acquiring land for renewable energy project(s).
- Renewable energy project investors both in public and private sectors shall be exempted from corporate income tax for a period of 5 years.
- An incentive tariff may be considered for electricity generated from renewable energy sources which may be 10% higher than the highest purchase price of electricity by the utility from private generators.
- To promote solar water heaters, use of electricity and gas for water heating will be discouraged. In this regard necessary steps will be considered accordingly.
- Renewable energy project(s), to sale electricity from plants shall be required to get power generation license from BERC if the capacity of the project(s) is 5 MW or more
- Power division of MPEMR and SEDA, in consultation with Bangladesh Power Regulatory Commission (BERC) will create a regulatory framework encouraging generation of electricity from renewable energy sources
- BERC shall approve the energy tariff in consultation with Power division of MPEMR/SEDA as per the provision of the BERC Act 2003 if the capacity of renewable energy project(s) is 5 MW or more. Electricity distributors may offer “green energy” tariffs, which provide consumers an opportunity to co-finance through their electricity bills the development of new renewable energy sources.

## Chapter Six

### Important R&D and other support institutions for promoting RET in the country and a review of their effectiveness

Different Institutes, Universities and Research organizations (both public and private) are carrying out Research and Development (R&D) activities on diversified fields of renewable energy technologies. R&D activities of Bangladesh are characterized by plethora of constraints, including lack of expert manpower and financial resources. Different organizations and their field of interest related to R&D of RETs are presented in table.

Table 1: Major R&D activities and institutions for RETs

Technology	Major Organizations	Remarks
Solar Photovoltaic/ Balance of system	LGED, RERC, GS, CMES, BAU, BUET, Rahimafrooz, Micro Electronics, Energy Systems	Manufacture of all the balance of system components (like Charge controller, Cable, Battery, Inverter, Converter etc.) is made locally.
Grid connected PV	RERC	1.1 kW powered system has been developed
Solar and Wind hybrid	LGED	At an island
Solar Water Heaters	RERC, BCSIR	Local design, fabrication and installation have been done
Improved Stoves	BCSIR, BRAC	Number of designs have been developed at BCSIR with three basic categories- (I) without chimney (II) with chimney and (III) with waste heat utilization.
Solar Cooker-Box Type	RERC, BCSIR, BRAC, CMES	The cooker is made of locally available raw materials.
Solar Cooker-Parabolic	BCSIR	BCSIR has successfully field-tested its design which can quickly raise water to boiling point under clear sunny days.
Solar Dryer	RERC, BCSIR, 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.
Briquetting Machine	KUET, BRRI	Under the "RET in Asia" program, BIT Khulna is developing better machines with longer screw life.
Biogas	BCSIR, LGED, BAU, BRAC, GS	Fixed-Dome type plants are indigenously designed and constructed.

Other institutions-

- Power Cell, SEDA of Ministry of Power, Energy and Mineral Resources
- Ministry of Environment and Forests
- Infrastructure Development Company Limited - IDCOL was established on 14 May 1997 by the Government of Bangladesh (GOB). The Company was licensed by Bangladesh

Bank as a non-bank financial institution (NBFI) on 5 January 1998. Since its inception, IDCOL is playing a major role in bridging the financing gap for developing medium and large-scale infrastructure and renewable energy projects in Bangladesh. In less than a decade, the company now stands as the market leader in private sector energy and infrastructure financing in Bangladesh. Under Rural Electrification and Renewable Energy Development Project (REREDP), IDCOL has 15 partner business organizations. Under National Domestic Biogas and Manure Programme (NDBMP), IDCOL has 14 construction partner organizations.

- Ava Renewable Energy Limited- Going to fabricate solar module locally.

## Chapter Seven

### Important success stories of the utilization of renewable energy

Different RETs realized till date are listed in the following table.

Table 1: Different RET realized till date and their potential

No.	Technology
1.	Solar home system
2.	Solar cooker Improved biomass cooker
3.	Biogas plants
4.	Biomass bracketing machines
5.	Micro hydro
6.	Biomass gasifier
7.	Wind power (with battery)
8.	Solar and Wind hybrid power
9.	Solar Water Heater
10.	Grid connected Wind power
11.	Wind and diesel hybrid
12.	Solar and diesel hybrid
13.	Solar Water Pumping
14.	Water pumping wind mill/Irrigation
15.	Centralized Solar Electrification/Mini grid

Summary of the success stories in renewable energy utilization is given in the following table.

Table 2: Wide scale use of RETs

No.	Technology	Number of units
1.	Solar home system	<ul style="list-style-type: none"> <li>• Above 300,000</li> <li>• Solar Battery Charging Station at Charmontaz Union, Golachipa, Patuakhali, output capacity is 1.6 Kwp; simultaneously can charge 16 batteries of different states of charge</li> <li>• Capacity of 10 Wp Solar Lantern each distributed among 100 remote households of Villages; Afzalpara, Bashuria, Gidaha, Kalichar, Kalihati Upazila under Kalihati Upazila/Thana of Tangail District</li> <li>• 6 Sets of Solar PV Vaccine Refrigerators for the Health Care Centres, Chittagong</li> <li>• Solar Powered Telephone Exchange (installed capacity 1.2 kWp) by Bangladesh T&amp;T Board</li> <li>• Railway Signaling System/Telecom by Bangladesh Railway</li> </ul>
2.	Solar cooker Improved biomass cooker	<p>In dissemination stage</p> <ul style="list-style-type: none"> <li>• Around 300,000</li> </ul>
3.	Biogas plants	<ul style="list-style-type: none"> <li>• Around 35,000 (15000 are functioning)</li> <li>• 3.5kW cow dung based power generation unit at Netrokona district</li> <li>• Two biogas units one at Kutubdia and the other at Kishoregonj which were based on human excreta</li> <li>• 10kW, 5000 birds of poultry , Faridpur Orphanage Institute</li> <li>• Landfill Gas Recovery in Dhaka, Waste Concern</li> <li>• Composing of organic waste in Dhaka (700 tons/day), Waste Concern</li> </ul>
4.	Biomass bracketing machines	<ul style="list-style-type: none"> <li>• Around 100</li> </ul>
5.	Micro hydro	<ul style="list-style-type: none"> <li>• 50kWp at Barkal Upazila, Rangamati District</li> <li>• 10kWp at Bamerchara, Chittagong</li> </ul>
6.	Biomass gasifier	<ul style="list-style-type: none"> <li>• 250kW, Kapasia, Gazipur</li> <li>• Biomass gasifier at Faridpur Muslim Mission. This gasifier could save up to 50% fuel wood.</li> </ul>
7.	Wind power (with battery)	<ul style="list-style-type: none"> <li>• 1000 kWp at Kutubdia Island, Cox's Bazar District (total 50 nos. of 20kWp capacity Stand Alone Type Wind Turbines)</li> </ul>
8.	Solar and Wind hybrid power	<ul style="list-style-type: none"> <li>• Wind, 5kWp-Solar,5kWp at St. Martins Island, Cox's Bazar</li> <li>• 400 Watt at Kuakata Sea-beach, Patuakhali.</li> </ul>
9.	Solar Water Heater	<ul style="list-style-type: none"> <li>• Ganasastha Sangtha</li> </ul>
10.	Grid connected Wind power	<ul style="list-style-type: none"> <li>• 0.90 MW at Muhuri Dam, Feni</li> </ul>

- |     |   |  |
|-----|---|--|
| 11. | Wind and diesel hybrid                          | <ul style="list-style-type: none"><li>• 3 1.5 kW and one 10 kW</li></ul>   |
| 12. | Solar and diesel hybrid                         | <ul style="list-style-type: none"><li>• Two base transceiver station</li></ul>   |
| 13. | Solar Water Pumping                             | <ul style="list-style-type: none"><li>• SPV pumping with 6kWp solar PV, Barind' region of Rajshahi division; fifty thousand liters of water/day from an average depth of fifty meters</li><li>• 2 Sets of 1.8kW Solar PV Submersible Water Pumps of 50,000 liters per day lifting capacity of each pump, Chittagong</li></ul>  |
| 14. | Water pumping wind mill Irrigation              | 1X1.0 Kw, 3X1.5 Kw, 1X10 Kw at Patenga, Chittagong   |
| 15. | Centralized Solar Electrification in /Mini grid | <ul style="list-style-type: none"><li>• 1.8 kWp, at Gangutia growth center for 50 shopkeepers</li><li>• 5kWp centralized A/C at Chokoria, Cox's Bazar</li><li>• 1 Set of 10 KW Centralized AC Market Electrification Systems for the electrification of more than 200 shops in each market., Chittagong</li><li>• Community Based Rural Village Electrification (installed capacity 1.2 kWp), ANNONDO (Dighinala).</li></ul> |
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## Chapter Eight

### Strengths and weakness of the renewable energy programme

#### Strengths-

- R&D activities have been done on major renewable energy technologies for Bangladesh environment
- Renewable Energy Policy has been formed
- Awareness among the policy maker and general people are increasing about RET and climate change
- Solar and Wind Energy Resource Assessment has been done

#### Barriers to greater utilization of Renewable Energy Technologies-

There are plenty of barriers hindering widespread deployment of potential RETs in Bangladesh. Different types of barriers experienced are discussed in the subsequent headings.

- Information Barriers- Lack of information among the public and policy makers about renewable energy resources, technical/economic information about RETs.
- Institutional Barriers- Absence of a dedicated national agency like Sustainable Energy Development Authority (SEDA) to plan, co-ordinate and finance.
- Technical Barriers- Local manufacturing and/or assembly of renewable energy technology components and equipment are currently limited.
- Market Barriers- The high upfront cost at the end user level for renewable energy is a major barrier.
- Economic, Financial and Financing Barriers- Lack of appropriate financing mechanisms for renewable energy except for SHS.
- Human Resource Barriers- Limited expertise on system design, installation, operation and maintenance of renewable energy technologies and on project development.

## Chapter Nine

### RET products manufactured in the country and major/important manufacturing firms

Some name of RET product manufacturing companies are given below.

Table 1: RET products manufactured in the country

RET product	Manufacturing firms
Charge controller for solar home system	Almost all companies working in solar energy
Batteries	Rahimafrooz, Rimso
Solar cooker	BRAC, CMES, GS
Selective surface for solar water heaters/ Solar Water Heaters	RERC
Biogas plants	GS
Ava Renewable Energy Ltd.	Solar module (going to fabricate)

## Nomenclature

RERC	Renewable Energy Research Centre
LGED	Local Government Engineering Department
GS	Grameen Shakti
CMES	Centre for Mass Education in Science
BUET	Bangladesh University of Engineering and Technology
Rahimafrooz	Rahimafrooz Renewable Energy Limited
BCSIR	Bangladesh Centre for Science and Industrial Research
BRAC	Bangladesh Rural Advancement Committee
BAU	Bangladesh Agricultural University
BFRI	Bangladesh Forest Research Institute
KUET	Khulna University of Engineering and Technology
BRRRI	Bangladesh Rice Research Institute.
BPDB	Bangladesh Power Development Board
REB	Rural Electrification Board
UNEP	United Nations Environment Program
GEF	Global Environment Facility
NREL	National Renewable Energy Laboratory
DLR	German Aerospace Centre
BMD	Bangladesh Meteorological Department
GTZ	German Technical Cooperation
SWERA	Solar and Wind Energy Resources Assessment
BBS	Bangladesh Bureau of Statistical
SEDA	Sustainable Energy Development Agency