Draft Final Report

PROMOTION OF RENEWABLE ENERGY, ENERGY EFFICIENCY AND GREENHOUSE GAS ABATEMENT (PREGA)

Bangladesh

Country Report

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CONVERSION FACTORS

Crude Oil	:	1000 Tonnes = 0.0427 PJ
Petroleum Product	:	1000 Tonnes = 0.0427 PJ
Coal/Coke	:	1000 Tonnes = 0.027 PJ
Natural Gas	:	1MMCF = 0.00099 PJ
Electricity	:	1 GWh = 0.0036 PJ
LPG	:	1000 Tonnes = 0.0427
Non-Wood Biomass	:	1000 Tonnes = 0.0125 PJ
Wood Fuel		1000 Tonnes = 0.0151 PJ
Dung	:	1000 Tonnes = 0.0116 PJ

Exchange Rate:

1 US $ = 59.50 Taka.

ABBREVIATIONS

ADB	Asian Development Bank
AEC	Atomic Energy Commission
AEZ	Agro Ecological Zones
AH	amp. hour
ALGAS	Asia Least-cost Greenhouse Gas Abatement Strategy
APO	Asian Productivity Organization
ARMCO	Associated Resources Management Company
BAPEX	Bangladesh Petroleum Exploration Co. Ltd.
BAU	Bangladesh Agricultural University
BAEC	Bangladesh Atomic Energy Commission
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Centre for Advanced Studies
BCSIR	Bangladesh Council of Scientific and Industrial Research
BD	Bangladesh
BEPP	Bangladesh Energy Planning Project
BOI	Board of Investment
BPDB	Bangladesh Power Development Board
BRAC	Bangladesh Rural Advancement Committee
BRDB	Bangladesh Rural Development Board
BSCIC	Bangladesh Small Cottage Industries Corporation
CDM	Clean Development Mechanism
CFL	compact fluorescent lamp
CIF	Cost, Insurance & Freight
CNG	compressed natural gas
DAE	Department of Agriculture Extension
DANIDA	Danish International Development Agency
DESA	Dhaka Electric Supply Authority
DESCO	Dhaka Electric Supply Co. Ltd.
DOE	Department of Environment
DOMC	domestic coal
EAC	Energy Audit Cell
EE	energy efficiency
EIA	Environmental Impact Assessment
ERA	Electric Reform Act
EQS	Environmental Quality Standard
ERC	Energy Regulatory Commission
ETSU	Energy Technology Support Unit (UK)
FFYP	Fifth Five-Year Plan
FY	Fiscal Year
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gases
GJ	gig joule
GOB	Government of Bangladesh
GS	Grameen Shakti
GWh	gigawatt hour
GWP	Global Warming Potential
HSD	high-speed diesel
HSFO	high sulphur furnace oil
HYV	high yielding varieties
IB	incandescent bulb
IDCOL	Infrastructure Development Company Ltd.
IEA	International Energy Agency

IFRD	Institute of Fuel Research and Development
IFST	Institute of Food Science & Technology
IMPC	imported coal
IPP	Independent Power Project
KWh	kilowatt-hour
LGED	Local Government Engineering Department
LPG	liquefied petroleum gas
LSFO	low sulphur furnace oil
MEMR	Ministry of Energy and Mineral Resources, GOB
MMCF	million cubic feet
MW	megawatt
NEMAP	National Environment Management Action Plan
NEP	National Energy Policy
NGO	nongovernmental organization
NPBS	Narsingdi Pallibidyut Samiti
PBS	Palli Bidyut Samiti
PGCB	Power Grid Co. of Bangladesh Ltd.
PJ	Petajoule, $1x10^{15}$ Joules
PKSF	Palli Karma Shahayak Foundation
PREGA	Promotion of Renewable Energy, Energy Efficiency and Greenhouse Gas Abatement
PSMP	Power System Master Plan
PV	photovoltaic
RE	renewable energy
REB	Rural Electrification Board
RET	renewable energy technology
SAARC	South Asian Association for Regional Cooperation
SBC	Sadharan Bima Corporation
SEC	Securities and Exchange Commission
SEMP	Sustainable Environment Management Project
SHD	sustainable human development
SHS	Solar Home System
SKO	superior kerosene oil
TJ	Terajoule, 1×10^{12} Joules
UFFL	Urea Fertilizer Factory Ltd., Ghorasal
UNCED	United Nations Conference on Environment and Development
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value added tax
VDP	Village Defense Party
VERC	Village Education Resource Center
WCED	World Commission on Environment and Development
Wp	Watt Peak

EXECUTIVE SUMMARY

1.1 Country Background

Bangladesh is located in the northeastern part of South Asia between $20^0 34'$ and $26^0 38'$ degree N. latitude and $88^0 01'$ and $92^0 41'$ degree E. longitude. The country is bounded by India on the west, north and northeast and Myanmar on the southeast, and the Bay of Bengal on the south. The land area of the country is 147,570 sq. kms. The limit of territorial water of Bangladesh is 12 nautical miles and the sea extending up to 200 nautical miles is the economic zone of Bangladesh (Bangladesh Map: Appendix-A).

Since independence in 1971, world community has identified Bangladesh either by its poverty or its vulnerability to natural calamity. The population has grown very fast, from 75 million at independence to 129.25 million in 2001 (female 49%). The size of population would be 161.8 million in 2015 and 182.31 million in 2025.

Bangladesh generally enjoys a subtropical monsoon climate. There are six seasons in a year; but agricultural seasons are mainly winter, summer and monsoon. Winter, which is quite pleasant, begins in November and ends in February. The maximum temperature recorded in summer months is 36.6 degree Celsius, although in some places this rises up to 45^o Celsius. Winter temperature may drop down to 4°C.

Although Bangladesh is predominantly an agricultural country, a large number of large-scale industries based on both indigenous and imported raw materials have been set-up. Among them jute, cotton, paper, sugar, chemical fertilizer, tanneries, etc are important. Other notable industries have been growing in iron, steel, painting, cable, ceramics, etc. Cottage industries have been contributing significantly in this sector. Through its export earnings, the garments sector plays an important role in boosting the economy of the nation, thus alleviating poverty.

The GDP growth from 1990-98 (9 years) are: 3.4, 4.2, 4.5, 4.2, 4.4, 5.3, 5.9, 5.7 and 5.2 percent respectively.

1.2 Energy Sector

Biomass, gas, oil, electricity and coal are the main sources of energy used in Bangladesh. The total amount of biomass fuel consumed in the country is about 39 million tonnes annually. The country's available non-renewable energy sources are: Natural Gas – 16.3 TCF, Coal – 1750 million tones, and Peat – 171 million tones.

Biomass fuels have significantly contributed the following to the development of the national energy sector.

(i) Domestic sector consumption decreased from 64.8% in 1990 to 60.4% in 2000.

(ii) Contribution of biomass fuels decreased from 73.1% in 1990 to 68.0% in 2000.

(iii) Industrial and commercial use of biomass fuels account for 13.8% in 1995 and 13.7% in 2000 of the total national energy consumption.

(iv) In 2000, the total energy consumption of the industrial sector was 206.4 PJ (Petajoule). Out of this amount, 128.6 PJ (62.3%) came from biomass fuels and the remaining 37.7% from commercial fuels. This shows that close to two-thirds of the energy consumed in industries was derived from biomass fuels. The current industrial consumption is almost one-third (35.7%) of the energy consumed in the domestic sector.

Domestic sector accounts for the major share (60.4%) of total energy consumption and energy used (mainly cooking) in this sector in a very inefficient way (efficiency varying between 5 and 15%)

necessitating immediate intervention in respect of EE or some alternatives. Inefficient use of biomass leads to higher cost of production in the industrial sector.

Substitution for biomass fuels can be made by other renewable sources, which are locally available. The renewable energy prospects in Bangladesh include wind, hydro, solar PV, solar thermal, geothermal, tidal wave, OTEC and biogas.

The maximum demand recast for FY 2000-01 was 3,250 MW, which could not be supplied due to shortage of generation of electricity. The supplied maximum demand was 3,084 MW. The generated electricity has been consumed by different kinds of consumers. Demand of electricity rises sharply in the evening from sunset and continues for 4-5 hours every day. Break down of sector-wise use of electricity is below:

		Energy in GWh	Percentage
(a)	Industrial	6,029	44.15
(b)	Commercial	1,075	7.87
(c)	Domestic	5,575	40.83
(d)	Agriculture	705	5.16
(e)	Others	272	1.99
	Total	13,656	100.00

It appears from the above that domestic and commercial consumers consumed the maximum percentage of 48.7% of electricity. Industries consumed 44.15% while Agriculture and others consumed about 7%. Pilferage of electricity from the system has been ignored.

1.3 Energy Policy

Access to electricity in Bangladesh is one of the lowest in the world as it presently covers less than 20% of the total country population. The rural areas of Bangladesh, where 76% of the population live, are seriously deprived of the electricity facility. Larger energy supplies and greater efficiency of energy use are thus necessary to meet the basic needs of a growing population. It will, therefore, be necessary to tap different sources of renewable energy (RE) resources, which are available considering economical and technical viability and keeping in view of the country's Environmental Quality Standards (EQS). Plant location, size and design will be considered on the basis of locally available energy resources and efficient conversion of energy will be given preference. Priority will be given to rural areas where national grid expansion is expensive. This will reduce the pressure on the demand of commercial power supply and will help avoid costly grid expansion and will also keep environment pollution-free.

In order to translate these policy objectives into actual investment projects, the Government of Bangladesh (GOB) has taken keen interest in finalizing and declaring an updated Energy Policy. Under the proposed Electricity Reform Act (ERA), there is also a provision to regulate the development and operation of RE. Until the Energy Regulatory Commission (ERC) is formed under the proposed ERA, Power Cell will carry out all primary and initial work related to development of renewable energy.

1.4 Technical Potential for REGA Technologies

Among the different renewable energy technologies (RETs), research, development and dissemination on improved biomass stoves, biogas plants, solar hot boxes, solar water heaters have achieved various degrees of success. All these devices are being made locally and GOB is funding projects for dissemination improved biomass stoves and biogas plants. Dissemination of solar home systems (SHS) is gaining momentum. Excepting solar module, accessories including Balance of System (BOS) like battery, controller, wires, sockets, switches, fluorescent tubes are made locally and easily available.

Under projects funded by the World Bank (2002), Rural Electrification Board (REB) and Infrastructure Development Co. Ltd (IDCOL) are planning to install solar PV of 0.7 MWp and 2.5 MWp respectively, over the next 5 years.

In 1984, the Energy Audit Cell (EAC) with technical assistance from Arthur D. Little International Inc and others made a survey and found that there was a potential annual saving of over 16.71 PJ in the industrial sector alone.

Under an ADB Technical Assistance No. 1973 – BAN, the latest systematic energy audits were carried out in 1993-94 by Technocosult International Limited, Bangladesh, in association with Acres International Limited, Canada and S. N. Corporation, USA, for some factories in the industrial sector. Energy saving potentials in the accredited factories under the study resulted to the following:

Name of factories audited:	Energy saving potential (%)
• UFFL, Gorashal	30
• Chittagong Steel Mills	-
• A K Khan Jute Mills	27
• Chittagong Textile Mills	29
• Chattak Cement Factory	26.5
• Panchagarh Sugar Mills	21
• Karnafully Paper Mills	31

As energy efficiency (EE) data are 10 years old, it necessary to update the data in the industry sector and undertake energy audits of new industries.

Some proven energy saving devices are: (i) digital intelligent motor controller, (ii) compact fluorescent lamp, (iii) digital electronic ballast, (iv) installation of energy efficient devices in power plants, (v) co-generation. Widespread use of these devices should be encouraged.

1.5 Skills and Institutional Capacities Relevant to REGA Technologies

Popularization of RETs is gaining momentum in Bangladesh. A good number of institutions are involved in planning, research, development and dissemination of these technologies. Over 5,000 skilled technicians are available for setting up efficient stoves and over 1,000 personnel have been trained on construction, operation and maintenance of biogas plants. Large number of skilled personnel is available for installation and maintenance of SHS.

As far as EE in industries is concerned, the Energy Audit Cell and the Asian Development Bank have undertaken some preliminary studies. The following observations are noted with regard to the status of capacity building in the country.

(i) Bangladesh has adequate expertise and institutional capacity for efficient stoves and biogas technologies.

(ii) For solar PV systems, institutions are growing rapidly for the manufacture of balance of systems (BOS, items other than PV module) and the installation and operation thereof. But the local manufacture of PV module is yet start.

(iii) Only three Global Environment Facility (GEF) projects are on record—one of them is currently under implementation. Projects under the Clean Development Mechanism (CDM) are yet to start. Expertise on GEF and CDM projects are being developed in some NGOs including Bangladesh Centre for Advance Studies (BCAS). Further capacity building in GFF and CDM will help expedite the preparation of bankable projects.

(iv) Formation of Renewable Energy Development Agency (REDA) is currently under consideration of the GOB. REDA will have the mandate to take necessary steps for development, promotion and utilization of renewable sources of energy.

(v) Energy Audit Cell (EAC) under the Ministry of Energy and Mineral Resources (MEMR), which is responsible for energy efficiency (EE) studies in industries and power generation plants are not adequately equipped in respect of manpower and equipment. Further strengthening of this cell is immediately needed.

(vi) Although PBS under the REB is given the responsibility of introducing solar PV systems in the rural areas, they need trained personnel dedicated alone to the solar systems. Same person appointed for both grid and off-grid options do not get interest in the latter.

(vii) Overall, there is adequate technical expertise in improved stoves and biogas technologies, and some expertise in solar systems. There is practically no expertise in other RETs and EE fields. A severe lack of capacity in government, non-government, private and financial sectors to appreciate, plan and finance RE and EE projects is a big barrier to RE development and EE improvement

Government has initiated several policy actions, which support activities under the UN Framework Convention on Climate Convention (UNFCCC), reduction of GHG and considerations on adaptation. Many of the key policies and actions are focused towards the sustainable development goals of the country.

Forests and forestland are important sinks or reservoirs of carbon, and have received adequate attention in the national development plans. A large part of the natural forest of the country has been set aside for conservation. Productivity will be increased through tree plantation with public participation as far as applicable. A total of 32,000 hectares agro-forest and woodlot plantation and 25,000 kilometers strip plantations was planned to be completed by 2002.

Tree plantation has become a major annual event and festival involving government, NGOs and local communities, adding significantly to carbon sequestration potential as well as supplying of nutrition for the rural poor by providing fruits.

In April 2001, the GOB has also setup a Working Committee for appropriate implementation of activities related to the UNFCCC. The GOB needs to setup new institutions and strengthen the existing institutes to deal with climate change and sustainable development issues.

1.6 Energy Policy

Access to electricity in Bangladesh is one of the lowest in the world presently covering less than 20% of the total country population. The rural areas of Bangladesh, where 76% of the population live, are seriously deprived of the electricity facility. Larger energy supplies and greater efficiency of energy use are thus necessary to meet the basic needs of a growing population. It will, therefore, be necessary to tap different sources of renewable energy (RE) sources, which are available considering economical and technical viability and keeping in view the Environmental Quality Standard (EQS). Plant location, size and design will be considered on the basis of available energy resources of the area and efficient conversion of energy will be given preference. Priority will be given to the rural areas where national grid expansion is expensive. This will reduce pressure on the demand of commercial power supply and will help avoid costly grid expansion and will also keep environment pollution-free.

In order to translate these policy objectives into actual investment projects, the Government of Bangladesh (GOB) has taken keen interest in finalizing and declaring an updated Energy Policy. Under the proposed Electricity Reform Act (ERA), there is also a provision to regulate the development and operation of RE. Until the Energy Regulatory Commission (ERC) is

formed under the proposed ERA, Power Cell will carry out all primary and initial work related to development of RE.

1.6 Sustainable Development Priorities

Although the national planning process has laid utmost importance on poverty alleviation and accelerating economic growth since the launching of the First Five Year Plan in the early 1970s, environment and sustainable development has not been recognized until the Fourth Five Year Plan (1990-1995). The inclusion of environment and sustainable development in the planning process is largely attributable to the worldwide concern for environment as manifested through the various international initiatives like the Stockholm Conference (1972), World Commission on Environment & Development (1987) and the UN Convention on Environment and Development (1992). Besides, there have been local initiatives by the scientists, NGOs, civil societies to create environmental awareness through series of workshops, seminars, conferences, etc.

Good potential of RE coupled with the sustainable development strategies of the GOB are expected to usher in a new era of RE development and utilization in Bangladesh.

1.7 Identification and Prioritization of REGA Technologies for Project Preparation

From the review of renewable energy, energy efficiency and GHG emission status and the current government policies given in the Chapters that follow, nine projects have been identified and recommended (in order of decreasing priority) to be developed into pre-feasibility studies under the PREGA project.

(i) Waste to electrical energy project
(2) Introduction of co-generation in sugar industries
(3) Solar-wind-diesel hybrid for power generation for small towns and villages
(4) Fuel switching from oil to gas for power generation
(5) Energy efficiency studies in industries
(6) Rehabilitation of electricity distribution network
(7) Combined cycle power plant in place of gas-steam power
(8) Conversion of gasoline cars to CNG cars
(9) Replacement of 2-stroke engines with 4-stroke engines for auto rickshaws

There are other projects, which may not qualify for CDM in the immediate future because of decentralized nature of accounting CO_2 reduction. The following projects have been identified for future consideration when appropriate accounting methods are made available.

(i) Solar electricity in the National Assembly building (Parliament Building), President's House, and Prime Minister's Office and Official Residence
(ii) Demonstration of efficient biomass stoves for widespread use
(iii) Demonstration of biogas plants for popularization
(iv) Demonstration of CFL and other efficient appliances for popularization
(v) Introduction of intelligent motor controllers for efficiency improvement in electrical sector
(vi) Power generation through biomass gasification
(vii) Introduction of mini hydro/micro hydro electricity.

1. COUNTRY BACKGROUND

1.1 Introduction

Bangladesh is located in the northeastern part of South Asia between $20^0 34'$ and $26^0 38'$ degree N. latitude and $88^0 01'$ and $92^0 41'$ degree E. longitude. The country is bounded by India on the west, the north and the northeast and Myanmar on the southeast and the Bay of Bengal on the south. The land area of the country is 147,570 sq. km. The limits of territorial water of Bangladesh is 12 nautical miles but the sea extending up to 200 nautical miles is the economic zone of the country.

The country has one language and good cultural harmony. There are six administrative divisions, 64 districts and 489 thanas. Since its independence in 1971, the world community has identified Bangladesh either by its poverty or by its vulnerability to natural calamity. The population has grown very fast, from 75 million in 1971 to 129.25 million in 2001 (female 49%) (Population Census, 2001). The size of population would be 161.8 million in 2015 and 182.31 million in 2025 (World Bank, 2000). About 77% live in the rural areas, while the rest in urban areas (BBS, 2001). Distribution of population on the basis of religion is 88% Muslims, 11 % Hindus, 1% Christians, Buddhists and others.

Average literacy rate is around 60% with women literacy rate as significantly below compared to national level. Infant mortality rate is 77 per 1,000, one doctor for 4,866 people and per capita calorie intake in Bangladesh declined from 2,300 calories in 1960 to 1,920 calories per day in 1990.

In recent years, economic development was not measured by the yearly growth of gross national product (GDP), but by the human development, distribution of resources and women access to decision-making and consumption of calories. However, GDP data are still widely used.

1.2 Climate

Bangladesh enjoys generally a subtropical monsoon climate. There are six seasons in a year; but agricultural seasons are mainly winter, summer and monsoon. Winter, which is quite pleasant, begins in November and ends in February. The maximum temperature recorded in summer months is 36.6 degree Celsius, although in some places this rises up to 45^o Celsius. Winter temperature may drop down to 4°C.

Monsoon starts in July and stays up to October. This period accounts for 80% of the total rainfall. Rainfall ranges from 1,194 mm to 3,454 mm a year. The temperature remains relatively high so that various tropical crops can grow well in the whole year. The distribution of rainfall is not regular in all seasons. However, agriculture and development economy mostly depend on the availability of water. Drought, salinity, and desertification affect the socioeconomic conditions of the people.

1.3 Population Growth

Table 1 shows that the population of Bangladesh will increase to 161.8 million in 2015. Though the population growth rate will decline, the absolute increase will be larger, thus the population of Bangladesh as a low-income country will continue to grow.

Table 1. Population Growth, 1980 – 2015

Total Population (Million)			**Average annual population growth rate**		**Age dependency ratio (proportion of working age population, 15-65)**		**Population aged 65 and above (% of total**		**Women aged 65 and above (per 100 men)**	
1980	1998	2015	1980-98	1998-2015	1980	1998	1988	2015	1998	2015
86.7	125.6	161.8	2.1	1.5	1.0	0.8	3.3	4.0	81	94

Source: World Bank, 2000.

1.4 Income and Expenditure Distribution

Table 2 shows that the gap between the poorest of the poor (bottom 5%) and richest of the rich (top 5%) is widening so far as income distribution aspect is concerned. In 1995-1996,income accruing to the highest 5 % of the household (23.6%) is about 27 times of the income accruing to the lowest 5% of the household (0.88%). The share of income of the bottom 5% has decreased from 1.03% in 1991-1992 to 0.88% in 1995-1996. On the contrary, the share of income of top 5% has increased from 18.85% to 23.62% over the same period indicating a higher degree of inequality in income distribution.

In the rural areas, the richest – poorest ratio in 1995/96 was found to be 19.7 and in 1991-1992 this ratio was 16.6. In 1995-1996, the lowest 20% of households in the rural areas were enjoying only 6.5% of income, whereas highest 20% of households enjoyed 45.8% of income.

Table 2. Percentage Distribution of Income Accruing to Households in Groups (Deciles) and Gini Coefficient

Family Group	Year – 2000	Year – 1995/96	Year –1991/92
National level	100.00	100.00	100.00
Lowest 5%	0.92	0.88	1.03
Decile – 1	2.40	2.24	2.58
Decile – 2	3.75	3.47	3.94
Decile – 3	4.45	4.46	4.95
Decile – 4	5.23	5.37	5.94
Decile – 5	6.09	6.35	7.08
Decile – 6	7.08	7.53	8.45
Decile – 7	8.44	9.15	10.09
Decile – 8	10.35	11.35	12.10
Decile – 9	13.93	15.40	15.64
Decile –10	38.14	34.68	29.23
Maximum 5%	28.66	23.62	18.85
Gini Index	0.417	0.432	0.338

Source: HES, 2001.

Geographical surface of Bangladesh is broadly categorized in five segments, namely (i) agricultural land 64%, (ii) forestland 18%, (iii) urban land 8%, (iv) water bodies 7%, and (v) others 3%. There are some undulating and hilly land region in the northeast and the southeast parts of the country. Remaining land area is low, flat and fertile with silt and loam. Recently, the land has been classified on the basis of Agro Ecological Zones (AEZ) in 30 segments. It is an alluvial flood plain of land conducive for crop production.

Table 3. Showing the Utilization of Land for Agriculture and Forest in Bangladesh (,000 Acres)

Year	Not available for cultivation	Forest	Cultural waste	Current fallow	Single cropped area	Double croppe d area	Triple croppe d area	Net area sown	Total croppe d area
1998-1999	9,141	5,572	1,100	1,115	7,408	9,914	2,419	19,741	34,493

Source: GOB, 2001.

1.5 Agriculture and Livestock

In agriculture, it is significant that the triple cropped area has been increasing though the land is limited. The arable land has been shrinking for conducting various development activities so that the increase of productivity through triple crop production is essential for food security and economic growth of the nation.

Land-based agriculture still remains the lead contributor to the growth of economy with a share of 37% to GDP in 1998, shrinking from 47% in 1987. It provides employment to 65% of the population. Cropping intensity is about 1.75. Availability of arable land per capita is less than 0.01 hectare. Only 10% of the rural households own about 50% of the cultivable land with half of the rural population being functionally landless. Recent studies show that there has been a link between landless and poverty plus migration from villages to towns. Rice covers about 80% of cultivable land of the country (PPA, 1999). High Yielding Variety (HYV) cultivation has ensured sufficient food grain production. But vegetable and other pulse crop production still remain short of the demand.

Livestock raising is the most common livelihood of households in Bangladesh. The last census in 1983-1984 shows that 23.2 million cattle, 0.8 million buffaloes, 29.08 million goats, about 1 million sheep, 116.5 million chickens and 13.5 million ducks were available in the country. This sub-sector of agriculture contributes almost 7% of the total GDP of the country. It provides draught-animals for agricultural operations and major source of animal protein for human consumption. It generates 13% of total foreign exchange earning through the export of hides, skins, leather and leather products. It provides fulltime employment for 20% of the rural people. In recent years, livestock has been growing in villages, with many enterprises and entrepreneurs producing feeds, cages and other tools and materials. However, medical facilities like vaccines, immunization and credits are inadequate to sustain the growth of the livestock sub-sector.

1.6 Forestry

The forestry sector is estimated to contribute around 3% of total GDP and provides employment to about 2% of the total employment generated in the country. Forest cover is about 15% of the country's total area but its distribution is not uniform over the country. Rajshahi division has a very small coverage of natural forest.

1.7 Industry and Business

The industrial sector contributing around 12% of the GDP is dominated by jute processing followed by cotton textile and cigarettes. Although Bangladesh is predominantly an agricultural country, a large number of large-scale industries based on both indigenous and imported raw materials have been set-up. Among them, jute, cotton, paper, sugar, chemical fertilizer, and tanneries are important. Other notable industries have been growing in iron, steel, painting, cable, ceramics, etc; Cottage industries have been contributing significantly in this sector.

Garments manufacturing and export is playing an important role in boosting the economic growth of the nation. Recently, GOB has reduced the interest rate for investors to enhance industrialization in the country.

The GDP growth from 1990–1998 ranged from 3.4 to 5.7. The figures of GDP growth do not imply that the country's economic development has been changing significantly. According to development activists, the GDP ignores human development indices like nutrient consumption, pure drinking water, sanitation and access to resources and education to the rural poor.

2. ENERGY SECTOR REVIEW

2.1 Energy-related Issues in Bangladesh

Since energy is used in domestic cooking, food processing and lighting, industries, transport, agriculture and other economic activities, energy-related problems now facing the country must be clearly identified. The current pressing problems are the following.

(i) Consumption of huge amount of biomass (about 39 million tons per year (GOB, 1996)) leading to shortage of organic matter needed for productivity of soil, feed for cattle, raw material for industries, fuel for domestic and industrial use.

(ii) Consumption of crop residues and cattle-dung as fuel in increasing amounts (about 50% of the total biomass leading to deficiency of organic matter and micronutrients in soil.

(iii) Rapid deforestation leading to erosion and change in climatic patterns.

(iv) Shortage of import-based diesel affecting irrigation leading to less agricultural production than expected.

(v) Inadequate availability of energy affecting growth and even maintenance of industries leading to unemployment.

Other energy-related issues include the following.

a. Over 100 million people of the country have no access to electricity.

b. People living in poverty pay a higher price per unit of energy services than the rich.

c. Improvements in energy efficiency have considerable potential to reduce poverty.

d. Women and children's time spent in fuel and water collection represents a high social and economic cost.

e. The pattern of energy use influences population growth.

f. Women and children have the highest exposure to indoor air pollution.

g. Energy can play a major role in stemming and reversing the problem of land degradation.

h. Energy imports represent a significant fraction of foreign exchange earnings.

i. Current energy consumption patterns contribute to unsustainability.

j. Energy must be an instrument for the achievement of sustainable development

These facts make it imperative for the GOB to develop and implement an effective action plan for generation of electricity from whatever sources available especially city wastes, renewable sources, natural gas, etc. and for efficiency improvement in generation and consumption. In the National Energy Plan (NEP, 1996) and the Fifth Five Year Plan (FFYP1997), GOB has placed special emphasis on the development and utilization of RE and improvement of EE.

2.2 National Energy Availability

Biomass, gas, oil, electricity and coal are the main sources of energy used in Bangladesh, Biomass comprises wood fuels such as fuel wood, charcoal, twigs and leaves, agricultural residues such as plant residues, paddy husk and bran, bagasse, jute sticks and animal dung such as cattle-, buffalo-, goat- and sheep dung. In 1996, the total amount of biomass fuel consumed was 39 million tonnes.

The country has a sizable deposit of natural gas. In the 20 gas fields so far discovered the total recoverable amount of gas is estimated at 16.3 TCF (Website, February 2002). The country uses 1.5 – 2.0 million tonnes of petroleum and petroleum products per year, almost the entire amount of which is imported claiming nearly two-thirds of the total export earnings. About 1,000 million tonnes of bituminous coal in Jamalganj-Jaipurhat area and also a deposit of 300 million tonnes similar quality coal at Barapukuria (Dinajpur) and 450 million tonnes at Khalashpur (Rangpur) have been discovered (PSMP, 1995). Being situated at a depth of over 900 meters thus making mining cost being high, any sizable quantity of Jamalganj-Jaipurhat coal may not be available in the near future for widespread use. Barapukuria coal, being situated at a depth of around 160 meters, is being mined for use in a power plant. The present demand of 0.1 to 0.15 million tonnes for coal is met by import and is almost exclusively used for brick burning.

At present, 230 MW is being harnessed from the Kaptai Dam. There is an estimated reserve of 171 million tonnes of peat spread over large areas in Faridpur (150 million tonnes), Khulna (8 million tonnes) and Sylhet (13 million tonnes) regions. As these areas remain under water during almost half of the year, winning cost of the peat will be rather high unless a technology suited to the local conditions could be developed.

The energy balances of Bangladesh for 1990 and 2000 are shown in Appendices B and B1. Following are the important points regarding the relative contributions of the commercial and biomass fuels in the national energy scene.

(i) Domestic sector consumption decreased from 64.8% in 1990 to 60.4% in 2000.
(ii) Contribution of biomass fuels decreased from 73.1% in 1990 to 68.0% in 2000.
(iii) Industrial and commercial use of biomass fuels account for 13.8% in 1995 and 13.7% in 2000 of the total national energy consumption.
(iv) In the industrial sector in 2000, out of the total of 206.4 PJ (Petajoule), 128.6 PJ (62.3%) comes from biomass fuels and the remaining 37.7% from commercial fuels showing that close to two-thirds of the energy consumed in industries are derived from biomass fuels. The industrial consumption is almost one-third (35.7%) of the energy consumed in the domestic sector. Energy consumptions by sector and also by source for the years 1990 and 2000 are shown in Figures1 to 4.

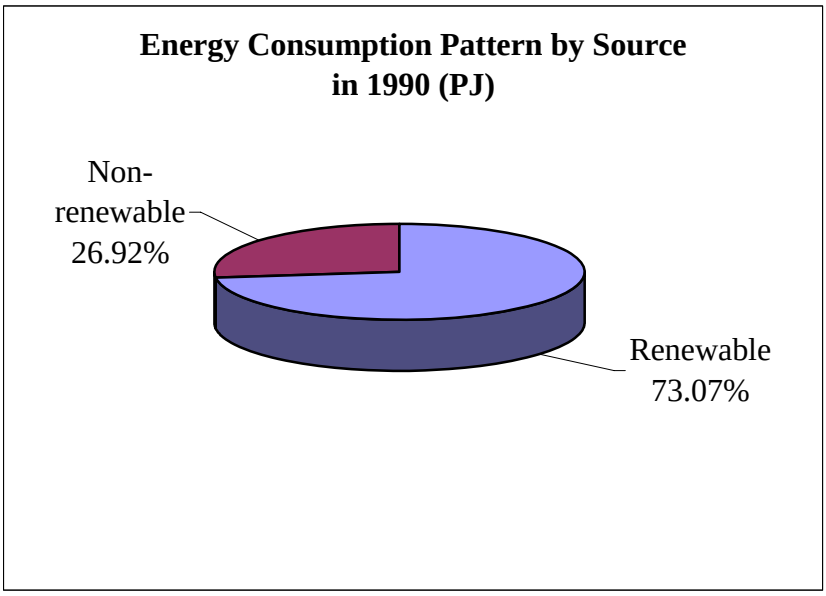


Figure 1. Energy Consumption Pattern by Source in 1990 (PJ)

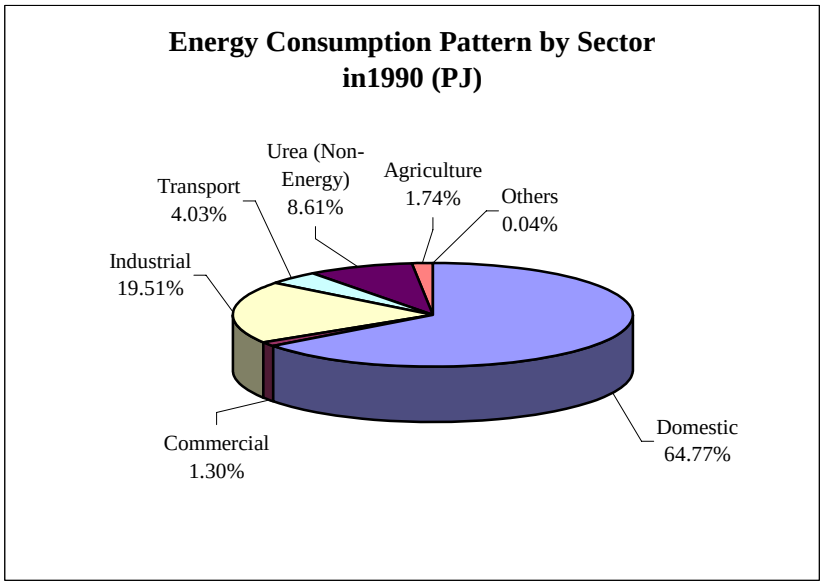


Figure 2. Energy Consumption Pattern by Sector in 1990 (PJ)

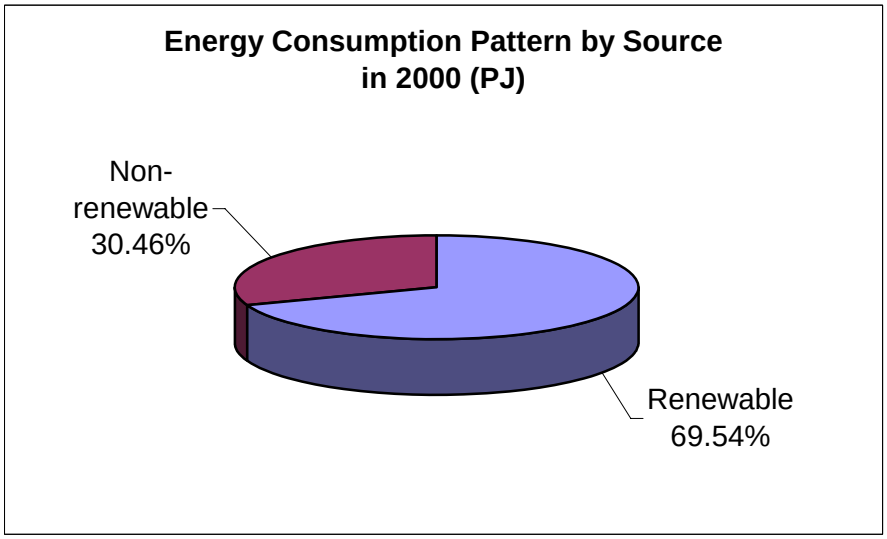


Figure 3. Energy Consumption Pattern by Source in 2000 (PJ)

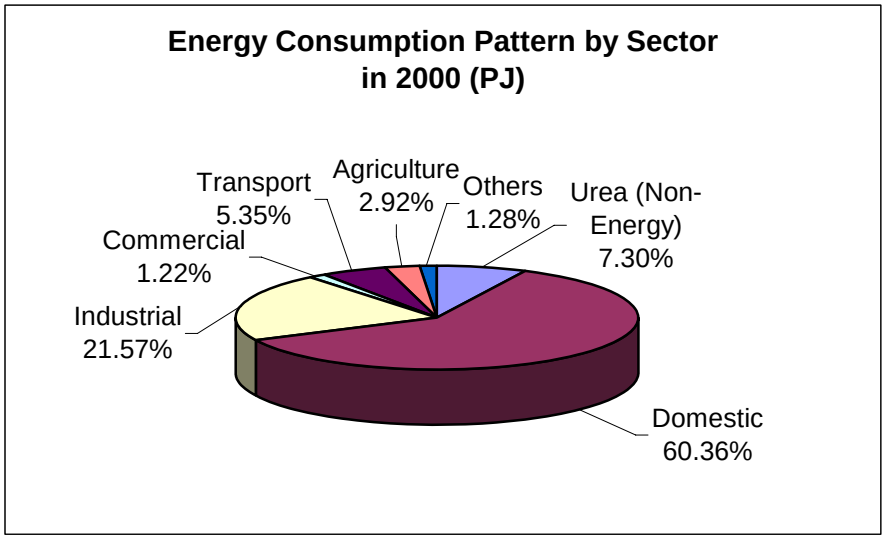


Figure 4. Energy Consumption Pattern by Sector in 2000 (PJ)

Available Non-renewable Energy Sources

Natural Gas	-	16.3 TCF
Coal	-	1,750 million tonnes
Peat	-	171 million tonnes

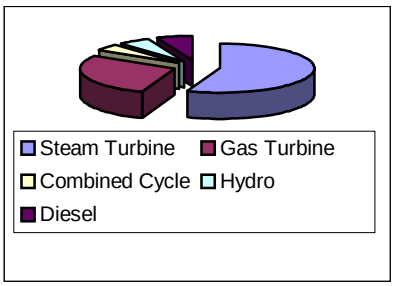
2.3 Power Demand

The maximum demand forecast for FY 2000-2001 was 3,250 MW, which could not be supplied due to shortage of generation of electricity. The supplied maximum demand was 3,084 MW.

The installed generation capacity was 4,005 MW, with BPDB having 3,420 MW and IPP, 585 MW. In addition, there are private generators that are not connected to the national grid.

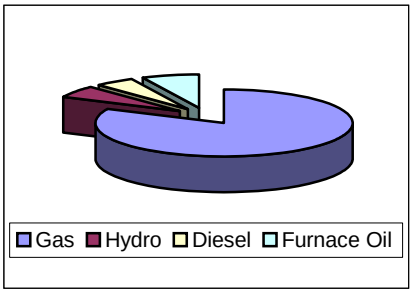
Installed capacity (by plant type) (BPDB, 2001)

	MW	%
1. Steam Turbine	2,228	55.55
2. Gas Turbine	1,129	28.22
3. Combined Cycle	180	4.49
4. Hydro	230	5.75
5. Diesel	238	5.99
Total	4,005	100.00



Installed Capacity (by fuel type)

	MW	%
1. Gas	3,281	81.89
2. Hydro	230	5.75
3. Diesel	204	5.12
4. Furnace Oil	290	7.27
Total	4,005	100.00



Gross Generation of Electricity by Fuel Type

	Energy in GWh	Percentage
1. Natural Gas	14,758	86.70
2. Hydro	1,012	5.95
3. Furnace Oil	439	2.58
4. Diesel	814	4.77
Total	17,023 GWh	100.00

Use of Electricity

The above-generated electricity has been consumed by different kinds of consumers. Below is the break down of sector-wise use of electricity.

		Energy in GWh	Percentage
(a)	Industrial	6029	44.15
(b)	Commercial	1075	7.87
(c)	Domestic	5575	40.83
(d)	Agriculture	705	5.16
(e)	Others	272	1.99
	Total	13,656 GWh	100.00

It appears from the above that domestic and commercial consumers consumed the maximum of 48.7% while industrial consumers consumed 44.15 %. Pilferage of electricity from the system has been ignored.

As shown in Figure 5, demand of electricity rises sharply in the evening from sunset and continues for 4-5 hours every day.

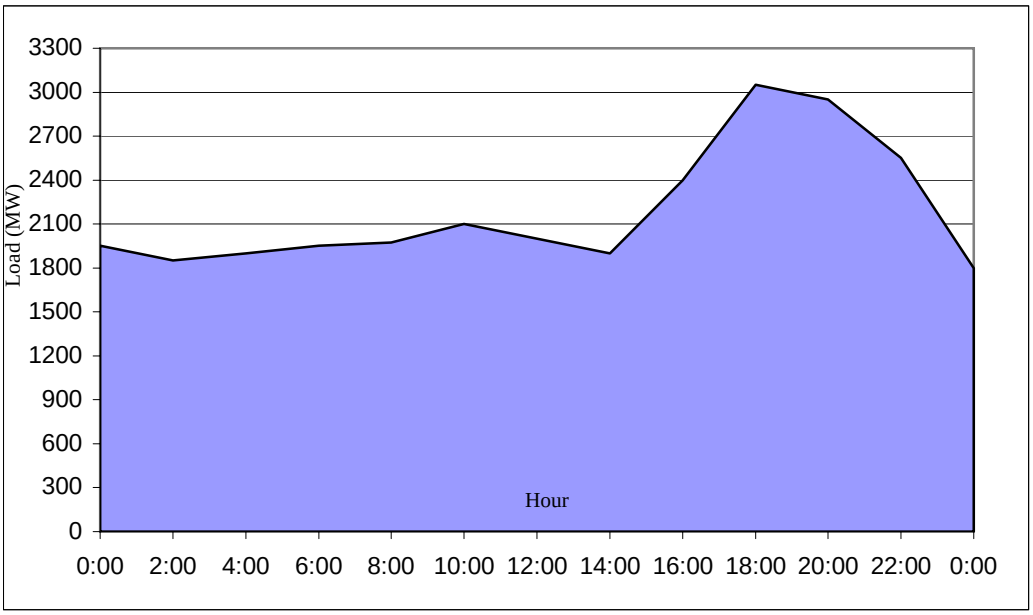


Figure 5. Daily Load Curve

The minimum demand of electricity occurs at midnight, while the maximum demand take place in the evening. The peak demand arises due to domestic, commercial, industrial and other light load. To meet this peak demand of the system, low efficiency generation like diesel generation, gas turbine plants as well as captive generators are required. Fuel cost of generators is high and the plant factor is low, thus unit cost of electricity becomes high.

Total net generation (BPDB + IPP) = 16257 GWh

Electricity produced by different types of fuel is as follows:

		Energy in GWh	Percentage
(a)	Natural Gas	14,758	86.70
(b)	Hydro	1,012	5.95
(c)	Diesel	812	4.77
(d)	Furnace Oil	439	2.58
	Total	17,011	100.00

Generation costs of electricity plant-wise and fuel-wise are given in Table 4 (BPDB, 2001). Costs per kWh vary from Tk. 0.611 in gas combined cycle to Tk. 0.907 gas turbine in the East zone and from Tk. 0.871 in gas turbine to Tk. 6.253 in oil fired gas turbine in the West zone. According to the National Energy Policy (NEP, 1996), trend of primary energy mix for power generation is estimated based on two economic growth rate scenarios, low and reference scenarios.

Table 4. Generation Costs, TK/kWh

Scenario	1990-1995	1995-2000	2000-2005	2005-2010	2010-2015	2015-2020
Low	4.44	5.25	5.24	5.24	6.65	6.65
Reference	5.0	6.0	6.7	7.2	7.5	8.0

Source: NEP, 1996.

Projected trend of the primary energy mix over this period is shown in Table 5 (NEP, 1996). It is seen that, even under the low scenario, increasingly larger deficits have to be met by imports. This clearly dictates that an all out drive is needed to explore other possibilities such as renewables on one hand and efficient electricity generation plants & consumption devices on the other. Tariff rates for electricity and gas are shown in Appendices C, D and E.

High costs per kWh for oil-fired and diesel stations in comparison with gas-fired stations dictate that, wherever possible and feasible, furnace oil and diesel should be replaced by gas. Many captive generators in the eastern zones also run on oil.

Table 5. Trend of Primary Energy Mix for Power Generation, GWh

Type	***1990***	***1995***	***2000***	***2005***	***2010***	***2015***	***2020***
Total Generation							
Low Scenario	8207	11584	18315	26063	30994	46491	61998
Ref. Scenario	8207	12280	18971	28060	39750	59858	92402
Gas	7285	10500	15000	15000	15000	15000	15000
Coal	0	0	1030	2000	2000	2000	2000
Hydro	800	800	1000	1000	1300	1300	1300
Total Generation from Indigenous Fuel	8085	11300	17030	18000	18300	18300	18300
Deficit+ Low Scenario	122	284	1285	8063	12694	28191	43698
Ref. Scenario	122	980	1941	10060	21450	41558	74102

+ To be generated by imported fuels
Source: NEP, 1996.

2.4 Energy Efficiency

There are some of the initiatives that were taken by the GOB in the past for energy efficiency improvement. During the late seventies and early part of eighties, GOB, with the help of Sir William Halcrow & Partners (UK) and others, launched the Bangladesh Energy Planning Project (BEPP, 1997), a national survey that showed a huge potential for energy savings in all sectors of economy in the country.

In 1984, GOB established the Energy Monitoring Unit (Now Energy Audit Cell) and associated it with the project named Bangladesh Energy Efficiency and Refinery Rehabilitation Project: Energy Efficiency Component that was launched under IDA Credit No. 1357-BD. Technical assistance was provided by the Development Partners Arthur D. Little International Inc in association with Bechtel Gr. Inc and Rahman Rahman Haque & Co. of Bangladesh in the following three areas.

(i) Energy Audit in 47 large and medium sized industries and power stations (comprised about 85% commercial energy consuming units). Development of data on energy use at the unit process level, quantify losses, identify cost-effective ways to improve the energy efficiency of operation.

(ii) Examine various institutional, legal, financial and educational issues that could act as barriers towards achieving energy efficiency goals.

(iii) Define an implementation program for the identified efficiency options in the industry.

The project findings in the year 1984 are shown in Tables 6 & 7. There was a potential of annual saving of 16.71 PJ in the industrial sector. Total commercial energy consumption in industries in 1983-1984 was 28.2 PJ (GOB, 1985).

Table 6. National Annual Energy Saving Potential by Sector, 1984

<.....Saving Potential 10^{15} J/yr .....>

Industry Sector	Thermal Energy	Electrical Energy	Traditional Energy	Co-Generation	Total Saving
Fertilizer	3.04	0.00	0.00	0.00	3.04
Power	1.87	0.00	0.00	0.00	1.87
Other Mineral	0.54	0.01	1.23	0.00	1.78
Rice Mill	0.00	0.09	1.67	0.00	1.76
Paper	1.05	0.07	0.09	0.09	1.30
Sugar	0.02	0.02	0.84	0.00	0.88
Food	0.16	0.04	0.34	0.47	1.01
Tea	0.22	0.01	0.23	0.04	0.5
Metal	0.41	0.02	0.00	0.00	0.43
Jute	0.21	0.07	0.07	0.27	0.62
Textiles	0.22	0.07	0.02	1.67	1.98
Cement	0.12	0.01	0.00	0.00	0.13
Glass	0.03	0.00	0.00	0.00	0.03
Miscella.	0.03	0.05	0.69	0.61	1.38
Total	**7.92**	**0.46**	**5.18**	**3.15**	**16.71**

Source: EAC (1986).

Table 7. National Annual Energy Efficiency Improvement Potential by Technology, 1984

Saving Options	National Energy Saving (PJ/yr)	Net National Cost Saving (Million $/yr)	National Investment (Million $)	Payback (Years)
House Keeping	4.83	6.26	6.65	1.05
Operation/ Maintenance	0.90	1.48	2.20	1.51
Combustion Control	4.33	8.51	9.90	1.17
Simple Retrofit	1.20	1.59	2.80	1.75
Turbine Heat	0.10	0.30	0.60	2.03

Rate				
Electrical	0.40	0.95	1.90	2.01
Process Improvement	1.80	3.39	7.80	2.30
Sub-total	**13.56**	**22.48**	**31.85**	
Co-generation	3.15	15.66	76.00	4.85
Fuel Switching	0.00	45.57	25.40	0.56
Total	**16.71**	**83.71**	**133.25**	

Source: EAC (1986)

Under TA 1973–BAN: Energy Conservation in the Industrial Sector, an ADB project, energy audits were carried out in 1993-1994 by Techno Consult International Limited, Bangladesh, in association with Acres International Limited, Canada and S. N. Corporation, USA, for some factories in the industrial sector (ADB,1996). Following are the energy saving potentials found under the study.

Name of factories audited:	**Energy saving potential (%)**
• UFFL, Gresham	30
• Citation Steel Mills	-
• A K Khan Jute Mills	27
• Citation Textile Mills	29
• Chattel Cement Factory	26.5
• Panchagarh Sugar Mills	21
• Karnafully Paper Mills	31

Although it did not cover all the factories in a particular sector, the study indicates a big potential for energy saving in industries. As the data is 10 years old and those in Tables 6 & 7 are almost 20 years old, it is therefore required to update the data and generate new data for new industries before starting implementation of any energy efficiency project in industries.

As seen in Table 7, cogeneration has a significant potential saving of 3.15PJ annually from textiles, food, jute, rice mill, tea and other industries. Seventeen sugar mills in the country process some $7x10^6$ tonnes of sugar canes annually (GOB, 2001).

2.5 Renewable Energy Potential and Possibilities

Being situated in hot, humid, sunny region and the landmass being criss-crossed by innumerable rivers and streams, Bangladesh is endowed with plentiful supply of renewable sources of energy. Out of the various renewables, solar, biomass, wind, and hydropower have been crudely used in Bangladesh over the years.

2.5.1 Solar energy

Solar energy is inexhaustible, pollution-free and available everywhere, but the greatest amount is available between two broad bands encircling the earth between 15° and 35° latitude north and south. Fortunately, Bangladesh is situated between 20°34′ north and 26°38′, north latitude and as such the country is in a very favorable position in respect of the utilization of solar energy. Annual amount of solar radiation varies from 1,840 to 1,975 kWh/m^2 (estimated from Hussain & Huda, 1996) that is 50-100% higher than in Europe. Taking an average solar radiation of 1900 kWh per square meter, total annual solar radiation in Bangladesh is equivalent to 1,010 x 10^{18} J. Present total yearly consumption of energy is about 1,000 x 10^{15} J. This shows that even if 0.1% of the incident radiation can be utilized, total requirement of energy in the country can be met.

2.5.2 Solar PV

In view of high solar insolation, PV potential is expected to be high. No estimate of the potential electricity production through solar PV is available. It is reasonable to assume that roofs of all the dwelling houses and cattle sheds may be used for fixing solar PV panels and this will not cause any space and resettlement problems. Average area per dwelling house is 168m² and per cattle shed 50m² (OFRD, 1987). According to 2001 census (BBS, 2001), the total number of households is 25.362 million and those possessing cattle are 8.17 million. Current roof area for dwelling houses and cattle sheds is therefore 25.36 x 168 + 8.17 x 50 = 4,670 x 10^6m². Because of sloping nature of the 4-part roof of the majority of houses, 50% area i.e., 2,335 x 10^6m² will be available for panel fixation. Taking 216 watt m² for average availability of solar insolation (see Sec. 3.5.1) and 10% efficiency for the solar cell, the estimated PV electricity-potential is 2,335x10^6x216x0.1 = 50,436 MW. With the increase of number of households, potential for PV electricity production will increase.

Introduction of solar PV systems has been in progress since 1980 but the total wattage up to December 2002 was just 1,000 kW. Main reasons for the slow progress are: (i) lack of awareness, (ii) lack of confidence among the users and suppliers due to low output during the rainy season, (iii) high initial cost, and (iv) small market. Use of PV systems in prestigious buildings like the National Assembly Building, Prime Minister's office, Bangladesh Secretariat Building, etc. will greatly help in enhancing awareness on this RE resource. To make up for low insolation in the rainy season, some kind of hybrid is needed.

2.5.3 Solar Thermal

With regard to solar thermal, there is a demand for hot water in hotels, hospitals, and industries and in cooking & parboiling. The Bangladesh Council of Scientific and Industrial Research (BCSIR) has sold some 800 dish-type solar cookers (800 m^2). Box-type solar cookers are also on sale in BCSIR. Average area covered by each cooker is 1 m². There are 2,500 pieces, which are ready for sale that may be sold out over the next 5 years. No estimate is available for hot water. If all the 19.44 million rural households are supplied with solar cookers, total area covered will be 19.44 x 10^6m². There are prospects for solar desalination and solar flat plate collectors, but no work has been done on solar thermal power generation.

2.5.4 Biomass

Two-thirds of the present total energy consumption is attributed to biomass, namely, fuel wood, cow-dung, straw, bagasse, etc (Table 5). Deforestation is reaching an alarming proportion because of population growth and other reasons.

2.5.5 Waste to Electrical Energy

Disposal of city wastes is a big problem for city dwellers as well as for the city government. Technologies are now available to convert this nuisance into electricity, which can be added to the national grid. The city of Dhaka generates wastes that are large enough to support a 30 MW plant using landfill technology.

2.5.6 Introduction of Co-generation in Sugar Industries

Sugar mills produce biomass known as baggase after crushing sugar canes. This bagasse is used for power generation and also as a source of process heat. The efficiency is very low as 19 kgs bagasse burnt can only produce 1 kWh of electricity. There is a scope for 10 times increase in efficiency thus lowering the cost of production leading to better incentives to farmers and lowering of GHG emissions.

2.5.7 Efficient Biomass Stoves for Widespread Use

Some 39 million tonnes of biomass fuels (fuel wood, straw, dung, twigs, etc.) are burnt annually giving rise to a lot of problems including loss of soil fertility leading to decrease in agricultural production, deforestation, sufferings of women, etc. BCSIR has developed improved stoves that save 50-70% biomass fuels and reduce emission of GHGs and disease causing gases such as carbon monoxide and oxides of nitrogen and particulates. By widespread use of improved stoves, some 20 million tonnes of biomass can be saved annually. This is equivalent to saving Taka 20 billion (US$ 336 million) annually (taking the average price of biomass as Tk.1.00 per kg) besides checking the harmful effects mentioned above. Up to December 2002, about 300,000 households have been provided with improved stoves. The penetration rate is slow because of the absence of a massive effort, which should include site-specific and biomass-specific designs of the stoves. A massive effort and strong GOB policy are needed to take improved stoves to 19.44 million rural households. Analyzing the penetration rate during the last decade, it is predicted that the cumulative number may not exceed half a million in the next 5 years.

2.5.8 Biogas Plants for Popularization

Biogas is a kind of fuel gas obtained by anaerobic digestion of any organic material that decomposes on standing. The residue left after gas evolution is a fertilizer rich in organic matter and plant nutrients. Being an agricultural country, Bangladesh has tremendous potential of biogas. From over 22 x 10^6 cattle heads, assuming 80% collection of cow dung, the total gas obtainable is 2,377 x 10^6 m^3 (0.037 m^3 per kg fresh dung) per year. Processing of human excreta will yield biogas to the tune of 1200 x 10^6 m^3 per year. 24% of the total population i.e. 0.24 x 130 = 31.2 million people live in the urban areas producing some 31.2 x 10^6 x 0.3 x 365 = 3.42 x 10^9kgs of household wastes annually. This has a potential of producing 3.42 x 10^9 x 0.046 = 157.3 x 10^6 m^3 of biogas. Moreover, water hyacinth, which is aplenty in Bangladesh in ponds and rivers, is a good source of biogas. It grows very rapidly and is capable of rapid multiplication in any place where water exists. It is a nuisance in agriculture, fisheries and navigation. Yield varies from 10 to 20 tonnes per year per acre. Excluding water hyacinth, total potential of biogas from cow dung, human excreta and urban wastes stand at 3,735 x 10^6 m^3 equivalent to 1.95 million tonnes of oil (1m^3 biogas = 22.31*10^6 Joules). Besides energy, this technology provides organic fertilizer boosting crop production, clean and hygienic environment decreasing the incidence of diseases and adds to aesthetic appearance of the household surroundings.

2.5.9 Power Generation Through Biomass Gasification

High-level technology for power generation directly from biomass is now readily available. Any kind of biomass fuels such as fuel wood, straw, bagasse, dry cattle dung, etc are used as a feed material for the generator. Experience on biomass gasifier is rather limited in Bangladesh. A 5-HP rice husk sterling engine was set up at Narayanganj in 1982 under the sponsorship of USAID. Overall thermal efficiency was 5-7%. The plant is not currently in operation.

More than 50% of the total annual biomass consumption comes from agricultural residues. Annual production of coconut shell is about 80,000 tonnes. These resources may be used as feed for gasifiers. Biomass gasifiers therefore hold promise for decentralized electricity production in rural areas.

2.5.10 Hydropower

The country, being mainly flat, has limited hydropower potential. At present 230 MW is being utilized in Karnafuli hydro station. PSMP (1995) estimate for total large and medium hydro potential is 510 MW. Rivers in the northwestern hilly region have a mini-hydro potential of 161 MW (Islam, 2002). A study by the Bangladesh Power Development Board and Bangladesh Water Development Board (Islam, 2002) has found 19 prospective sites for installation of small hydropower with a potential of 1.2 MW. BCSIR and Local Government Engineering Department (LGED) are studying the micro-hydro potential in the country. At present, there is no mini- or micro-hydro plant in the country. Infrastructure Development Company Ltd. (IDCOL) is planning to setup a 5 MW mini-hydro plant within next year (WB, 2002) to be financed by the World Bank. There are a good number of promising locations for micro-hydropower plants.

2.5.11 Wind Power

The potential for wind energy in the coastal areas of Bangladesh is good. Efforts have been made by different organizations including Bangladesh Atomic Energy Commission (BAEC), BCAS and LGED (WEST, 1998) to monitor wind speeds at different coastal locations. Data so far collected justify wind energy generator projects in the coast. Wind may be included in a hybrid with PV and diesel.

Fulton (1996) estimates a wind potential of 2,000 MW along the coast based on BAEC findings. Small wind turbines so far installed add to a total of 50 kW only (Bakht, 2002) and some 5 MW would be installed within the next 5 years (WB, 2002).

2.5.12 Geothermal

There is a hot salt-water spring at Sitakunda, about 40 kms. from Chittagong. Feasibility of extracting energy from this site has never been undertaken. Study may also be undertaken to locate possible new sites.

2.5.13 Tidal, Wave and OTEC

The country has 710 kms long coastal belt along the Bay of Bengal. Tidal levels vary between 2 and 8 metres (Islam, 2002). A demonstration tidal power plant is being planned in Sandwip, a coastal island, by Murduch University, Australia. If successful, tidal energy will introduce a new dimension in the energy scene of the coastal region.

No systematic study has been undertaken on wave power and OTEC possibilities in the Bay of Bengal. According to Islam (2002), OTEC projects may be feasible in future. Present status, and plans over the next 5 years and estimated potential are summarized in Table 8.

Table 8. Renewable Energy Prospects in Bangladesh

Type	Current Capacity (Upto December 2002) [(a)]	Capacity Expansion over next 5 years	Potential
Wind	50 kW	5 MW [(b)]	2000 MW [(d)]
Hydro	230 MW	5 MW [(b)]	672 MW [(e)]
Solar PV	1026 kW	3.2 MW [(b)]	50,436 MW [(f)]
Solar Thermal	800 m^2	2,000 m^2 [(c)]	20×10^6 m^2 [(f)]
Geothermal	Nil	No programme undertaken	Needs investigation
Tidal, wave, OTEC	Nil	–	Needs investigation
Biogas	50,000 m^3	220,000 m^3 [(c)]	$3,675 \times 10^6$ m^3 [(f)]
Energy Saving per year through Improved stoves	**4.7 PJ**	**7.8 PJ [(c)]**	**312.5 PJ [(f)]**

Sources: (a) *Based on surveys by the NTEs*
(b) World Bank, 2002
(c) Private Communication from BCSIR
(d) Fulton, 1996
(e) Islam, 2002
(f) Estimated by the NTEs

3. TECHNICAL POTENTIAL FOR REGA TECHNOLOGIES

3.1 Basic Forms of Technology

Renewable energy can be utilized in four basic forms: liquid transport fuels, centralized electric power, decentralized power and heat as shown in Table 9. Among these technologies, small-scale solar, biomass utilization including biogas, wind have already been found feasible for rapid proliferation in a decentralized mode. Other technologies mentioned in Table 9 are also promising; but they need suitable support for research, development and demonstration.

3.2 Efficient Stoves

In the Institute of Fuel Research and Development (IFRD), BCSIR, both single and multiple stoves have been modified to give fuel saving to the extent of 50-70% when compared with the unmodified ones (Eusuf et al., 1993). Single-mouth stove saves 50-60% fuel, the highest overall efficiency being 30%. In the case of multiple stoves, fuel saving to the extent 60-70% is achieved. Moreover, the kitchen is completely free of flue gases and as such does not get heated. Multiple stoves reduce the cooking time to almost half and offer more comfort to cooking. The cost of these stoves vary from Taka 100/= for the single mouth stoves to Taka 2000/= for the institutional/industrial stoves.

Table 9. New and Renewable Energy Technologies and Applications

Energy sources		Liquid fuels	Centralized electric power	Decentralized power	Heat
1.	Solar		Thermal electric, photovoltaic, solar pond	Thermal electric, photovoltaic	Solar passive, Solar pond, Solar flat plate, Evacuated tube, Solar concentrators
2.	Geothermal		Geothermal electric	Geothermal small power	Geothermal Direct heat
3.	Wind			Wind electric	Wind electric, Wind shaft
4.	Hydropower		Hydropower (including small hydro)	Mini hydro Micro hydro	
5.	Biomass	Ethanol, Methanol, Vegetable oils	Direct combustion	1. Diesel with Liquid biofuel	1. Direct combustion
6.	Fuel-wood		Direct combustion		Direct combustion of wood and charcoal
7.	Oil shale and tar sands	Syn-crude	Shale burning		Liquid fuel for cooking
8.	Ocean/energy		Tidal, OTEC, Wave	Wave	
9.	Draught animal			Traction and shaft power	

3.3 Biogas

Currently, two biogas models are in use. In the floating-cover design, the gas pressure remains the same because of the up and down movement of the gasholder. In the fixed-top design, pressure varies with the accumulation of gas because of the displacement of the slurry from the digester.

3.4 Briquette

Briquette is a dense, compact and consolidated form of loose biomass produced through the application of pressure and temperature. Agro-residues and agro-based industry residues are conveniently converted into briquettes, which are considered as alternative of fuel wood and coal. The technology of briquetting is relatively new in Bangladesh. Briquettes are made with and without binder. Revolving screw type, reciprocating ram type and piston type machines are used for production of briquettes. Because of large contribution of loose residues to cooking and parboiling fuel, Bangladesh has a good potential for briquette industry. The cost of a briquetting plant of capacity 500 kg briquette per day is Tk. 100,000/= approximately.

3.5 Solar Cooker, Solar Hot Box and Solar Dryer

Dish type solar cookers are on sale in BCSIR at a subsidized cost of Tk. 350 per unit. Different models of solar ovens have been designed and constructed with locally available raw materials in IFRD. On a clear sunny day, an oven of size 50 cms. X 50 cms. X 10 cms. take about 2 ½-3.0 hrs. to cook three items viz. rice, meat/fish, pulses for lunch of a family of 5-7 members in Bangladesh. Solar cookers can prepare pudding and cake besides normal food items. Additional advantages of solar cookers include the following.

(i) No attention is required at the time of cooking.
(ii) Both diffuse and direct radiations are utilized, thus permitting cooking in partly cloudy conditions.
(iii) Cooked food is nutritious and pollution free.
(iv) Foodstuffs may be kept warm even after sunset.

The manufacturing cost of such an oven is about Tk. 1,000 excluding the cost of cooking pot. These models are on sale in IFRD. The Institute of Food Science and Technology, (IFST), and BCSIR has developed a cabinet dryer for drying fruits, vegetables, etc. by simply spreading a transparent cover over a box. The boxes must have openings for air circulation. These dryers are made of bamboo and polythene sheet. These dryers are being disseminated for rural application through training. The manufacturing cost of a cabinet dryer (6 feet x 2 feet) is about Tk. 3,000. Because of the simplicity of the technology and the low cost of constructions, they are within the reach of the rural farmers.

3.6 Solar Water Heater

Solar water heater is basically a flat-plate collector in which heat transfer fluid is water. This heater is designed and constructed by IFRD on request. Price of an 8ft x 4ft water heater delivering 20 liters of water at 82°C at noon in March is Tk. 10,000 approximately.

3.7 Photovoltaic (PV) Systems

In photovoltaic systems, sunlight is converted into electrical energy by a device called solar cells that are semi-conductors. Facilities for fabrication of solar cells are yet to be created in Bangladesh. Balance of System like batteries, controllers, wires, sockets, switches, tubes etc are made locally.

PV systems are being installed in some remote villages of Narshingdi district under a pilot project by REB, in cyclone centers and other places by LGED, Rahim Afrooz, Grameen Shakti, BRAC and many others.

3.8 Energy Saving Devices

3.8.1 Energy Saving from Motors

According to preliminary studies, approximately 60% of the country's daily electric power consumption is used to run electric motors and up to 40% of the power consumed by these motors

produce no 'useful' output. The digital Intelligent Motor Controllers (IMC), when installed with an induction motor, provides optimal power management and results in energy savings up to 40%. The IMCs also increase appliance motor's life by decreasing the motor's operating temperature. It is estimated that with the application of the IMCs, saving up to 720 MW electricity can be achieved.

3.8.2 Energy Saving from Energy Efficient Lamps

At present, there are more than 5 million consumers of electricity in the country. Assuming only 2 incandescent bulbs (IB) per consumer, there are 10 million IBs in the country. The compact fluorescent lamps (CFL) can give the same illumination as that of an IB with 80% less energy. The IBs generate 85% heat and 15% light. The CFLs generate 85% light and 15% heat. Moreover, the life span of CFLs is 10 times higher than IBs. So, energy efficient CFLs can be used to reduce the peak loads demand of the country in the evening.

3.8.3 Energy Saving from Electronic Ballasts

With the conventional fluorescent lamps, magnetic ballasts, which consume about 25 Watt, are used. The digital Electronic Ballasts (EBT) when installed with fluorescent lamps, provide optimal power management and result in energy saving up to 40%.

3.8.4 Energy Saving in Power Plants

In Bangladesh, auxiliary consumption of the power plants is about 6-7% of total generation. Auxiliary power consumption in the power plants can be reduced significantly through proper energy auditing, energy management and installation of the latest energy efficient devices. These devices, although very efficient, are yet to gain popularity.

3.9 GHG Mitigation Potential

3.9.1 GHG Emissions Inventory

The Asia Least-cost Greenhouse Gas Abatement Strategy (ADB, 1998) project conducted a comprehensive inventory of emissions in 1990 for energy, agriculture and livestock, and forestry and land-use changes using IPCC methodology. ALGAS studies revealed that per capita emission of greenhouse gas for Bangladesh in terms of CO_2 equivalent is less than a tonne, about 670 kg per year. The detailed estimate revealed that total GHG emission of the country is 72 million tonnes in CO_2 equivalent of which agricultural and livestock sub-sector has highest contribution i.e. 40 percent. Energy sector and Forestry sector including land-use change contributes about 30 and 27 percent, respectively. Remaining comes from industrial processing sub-sector (Table 10).

Table 10. Emission of Greenhouse Gas in 1990 (Kilotonne)

Sl. No.	Sources and Sinks	CO_2 Equivalent (excluding CO_2 emission from TBB)	Percent of Total CO_2 Equivalent
	Net National Emissions	72000	100.00%
1.	All Energy (Fuel Combustion + Fugitive)	21186	29.43%
	A. Fuel Combustion		
	1. Energy and Transformation Industries	4392	6.10%
	2. Industry	3050	4.24%
	3. Transport	1875	2.60%
	4. Commercial-institutional	259	0.36%
	5. Agriculture	680	0.94%
	6. Residential	5523	7.67%

	7. Others	400	0.56%
	8. Traditional biomass Burned for Energy	4084	5.67%
	B. Fugitive Emission		
	1. Oil and Natural Gas Systems	149	0.21%
2.	Industrial Processes	1491	2.07%
	1. Cement Production	153	0.21%
	2. Ammonia Production	1130	1.57%
	3. Metal (iron & steel)	208	0.29%
3.	Agriculture	28667	39.82%
4.	Land use Change and Forestry	19738	27.41%

Source: ADB (1998).

Note:

TBB stands for Traditional Biomass Burning

CO_2 emissions from traditional biomass burning are not included in subtotals and the national total.

CO_2 equivalents are based on GWPs of 21 for CH_4 and 310 for N_2O. NO_x and CO are not included since GWPs have not been developed for these gases.

3.9.2 Potential Sector for Abatement of GHG (ADB, 1998)

The country has not yet developed a strategy for the implementation of the United Nations Convention on Climate Change (UNFCCC) in the arena of GHG mitigation and not committed to do so. However, the following areas could be considered as national priority, which have significant GHG mitigation potential and in meeting the development needs of the country.

(i) Power Generation: The present technology is often old and inefficient and can be replaced with significant GHG reduction potential. Recent discovery and increasing availability of domestic natural gas make energy production environment friendly, thus consistent with government energy policy.

(ii) Industry Sector: Sector as a whole, or in terms of improvement of efficiency of energy using technologies/equipment such as boilers or motors deserve special attention.

(iii) Transport Sector: This sector is highly polluting and has significant potential to improve its efficiency. Urban transport is a major consumer; the imperatives of cutting down on the energy consumption of a large consumer have both health and GHG reduction impact. Conversion of gasoline cars to CNG cars and 2-stroke engines to 4-stroke engines are already on a high priority.

(iv) Cooling System: Present system is often old and inefficient. The efficient cooling devices for refrigeration and air-conditioning should be encouraged as much as possible.

(v) Forestry Sector: It could be an important carbon sequestrator and could bring important socioeconomic benefits particularly for the rural poor. In the government organized forestry sector, afforestation opportunities are significant and social forestry has emerged as a major social movement.

(vi) Improved Cooking Stoves: As one of the most promising GHG abatement options, improved cooking stoves can lower pressure on biomass demand i.e. deforestation. It also has significant health benefit for the poor and rural women.

3.9.3 GHG Mitigation Options and Opportunities

Given the general policy and regulatory needs, the following specific needs for implementing various policy recommendations are likely to arise in the near future:

(i) Awareness Campaign. With the help of the Ministry of Environment and Forest, the Department of Environment, and the Ministry of Science and Information & Communication Technology, the Ministry of Information should launch a major awareness campaign regarding the need for environmental conservation and GHGs abatement and their links with economic development in the country. There should be a separate campaign targeted for senior policymakers.

(ii) Industrial Energy use Efficiency. This was identified as one of the most important sectoral measure from the viewpoint of GHGs abatement. However, industrialist may hardly notice the need for improved efficiency. Private entrepreneurs may also therefore, need to be made aware of the benefits they may reap and the implementation methods.

3.9.4 Least-Cost GHG Mitigation Projects

The ALGAS study developed the following six investment projects, three of which were identified by the modeling exercise, and the other three by national prioritization exercise.

(i) Gas-based power generation,
(ii) Replacement of Incandescent Bulbs with Compact Fluorescent Lamps,
(iii) Phasing two-stroke engines with four-stroke engines for auto-rickshaw.
(iv) Dissemination of Improved Cooking Stoves in Rural Areas,
(v) Conversion of Gasoline Cars to CNG-driven cars,
(vi) Solar Electricity with Photovoltaic (Solar) Systems.

4. SKILLS AND INSTITUTIONAL CAPACITIES RELEVANT TO REGA TECHNOLOGIES

4.1 Institutions in the Energy Sector

Energy planning is the responsibility of the Planning Commission. Its Industry and Energy Division is responsible for all sources of energy including rural and renewable energy. Ministries involved in the energy sector including biomass resources are: (i) Ministry of Energy and Mineral Resources (MEMR), (ii) Ministry of Environment and Forest (MOEF), (iii) Ministry of Agriculture, (iv) Ministry of Fisheries and Livestock, and (v) Ministry of Science and Communication & Information Technology.

The MEMR is responsible for development and management of conventional energy sources including renewable energy excepting biomass resources. The entities under this Ministry and their corresponding functions are below.

(i) Generation
- Bangladesh Power Development Board (BPDB)
- Rural Electrification Board (REB)
- Private Power Generation Companies.

(ii) Transmission
- Bangladesh Power Development Board
- Power Grid Company of Bangladesh Ltd.

(iii) Distribution
- Bangladesh Power Development Board
- Dhaka Electric Supply Authority (DESA)
- Dhaka Electric Supply Company Ltd. (DESCO)
- Rural Electrification Board through Rural Electric Cooperatives (Palli Bidyut Samiti).

BPDB, DESA and DESCO supply electricity mainly to the cities and towns, while REB distributes electricity to the rural areas through cooperatives known as Palli Bidyut Samities (Rural Electric Co-operatives). REB has, by now, installed solar PV systems of 62.5 kWp under a French financial grant of US$ 1.1 million and a GOB grant of Taka 27 million (US$ 675,000). REB is currently planning to install solar home systems (SHS) of 0.7 MWp under a project of the World Bank. BPDB has also started setting up SHS in remote areas.

The development of forestry biomass, agricultural biomass and livestock biomass are the responsibilities of the Ministry of Environment and Forest, the Ministry of Agriculture and the Ministry of Fisheries and Livestock, respectively. The Ministry of Science and Information & Communication Technology looks after R&D activities related to energy development and utilization.

4.2 Renewable Energy Technologies (RETs)

Development and dissemination of RETs is gaining momentum. A good number of institutions are already involved (number increasing) in planning, research, development and dissemination of these technologies.

At the initial stage, acceptability studies of the developed models are the responsibility of developers. A dissemination strategy to be successful must take into consideration the nature of technology to be disseminated and the socioeconomic structure of its recipients. It is believed by some that a technology developed in a laboratory should be leased out, as done in developed countries, to intending entrepreneurs who will do the needful to take the technology to the door of the common man. This strategy is applicable if some secrecy can be maintained about the technology; but in the case of improved stoves and some other RETs, anybody can modify these technologies. An entrepreneur is

therefore not likely to take lease of these technologies because, the devices made by him may not find too many customers. Secondly, it is not easy to introduce a new technology in the rural areas. The correct strategy could be to distribute some prototypes to some interested parties for demonstration purpose and not with the intention of making profit. If the demonstration is successful, only then that large-scale demonstration may be undertaken. With a view to achieving these objectives, the IFRD of BCSIR has followed the following strategies in implementing projects financed by GOB.

(i) Awareness creation by advertisement through mass media, seminars and demonstrations
(ii) Creation of technicians through training. Over 5,000 rural youths have so far been trained.
(iii) Participatory approach through participation of government, semi-government, non-government and private organizations.

4.2.1 Fuel Saving Project

Under a scheme entitled "Fuel Saving Project" financed by GOB, the IFRD of BCSIR undertook training program for rural unemployed youths and setting up of demonstration models of improved stoves, during the period June 1988 – June 1991. The expenditure in respect of stoves was Tk. 8.185 million.

The progress achieved under the project is shown in Table 11. In 33 thanas, 133,841 improved stoves have been built through the participation of six central NGOs. Number of persons trained was 3,807. These trainees were given remuneration for building improved stoves at the rate of Tk. 20/- for single-mouth stove, Tk.30/- for double-mouth stove and Tk.50/- for chimney stove.

Table 11. Improved Stoves Dissemination Under Fuel Saving Project, 1988-1991

Phase	Monitoring Institution	No. of NGOS	No. of thanas	No. of people trained	No. of improved stoves installed
1st phase	IFRD	3	3	510	15,000
2nd phase	IFRD	3	6	625	24,686
3rd phase	IFRD	6	24	2672	94,155
			33	3807	1,33,841

4.2.2 Second Project on Dissemination of Improved Stoves (Period: 1994-1997)

This project was financed by the GOB, the IFRD of BCSIR in collaboration with Ansar-VDP and BRDB for Tk. 15.1 million. The installation of 66,990 improved stoves in 105 Thanas of 35 districts (3 Thanas in each district) was completed during the period July 1994 – June 1997.

Under this project, 35 supervisors (one in each district) were appointed to supervise construction, operation and maintenance of improved stoves. In each district, 25 youths were given one weeklong training on improved stoves to provide assistance in the installation of stoves and backup services.

4.2.3 Monitoring and Evaluation of Improved Stoves

The scientists of IFRD visited the thanas to study the progress of the dissemination of improved stoves and also the quality of the stoves built by the trainees. At the initial stages stoves were not fully in accordance to design and as such, the experts have made modification in the presence of the trainees. These follow up activities have proved to be useful.

The following government, semi-government and autonomous agencies, international and nongovernmental organizations have been in some way or the other associated with promotion of these stoves.

- Ministry of Science and Information & Communication Technology

- Ministry of Women's Affairs
- Bangladesh Council of Scientific and Industrial Research (BCSIR)
- Bangladesh Rural Development Board (BRDB)
- Bangladesh Rice Research Institute (BRRI)
- Department of Agricultural Extension (DAE)
- United Nations Children's Funds (UNICEF)
- World Vision
- Swanirvar Bangladesh
- Village Education Resources Centre (VERC)
- Bangladesh Association of Community Education (BACE)
- Bandhujan Parishad
- AID-Bangladesh
- Together for Service of People (TSP)
- Chashi Kallyan Samiti
- National Christian Fellowship of Bangladesh
- Concern Bangladesh
- Bangla-German Sampriti

4.2.4 Biogas Digester

In the IFRD of BCSIR, optimum design parameters have been established and cost optimization has been done. The cost of a family size biogas plant was reduced in 1981 to Tk. 3000/- (US$ 120). The construction and performance of the design have been described (Eusuf et al.1986).

Fixed-dome models built during 1980s were not leak-proof, and as such gas production and utilization were not satisfactory. In 1991, the Institute of Fuel Research and Development (IFRD) was able to develop leak-proof designs based on local materials. The advantage of the fixed-dome model over the floating-dome one is that the durability of the former, once leak-proof, is over 20 years; whereas the latter, though usually leak-proof initially, develop leaks due to corrosion within 3-6 years of operation depending on the thickness of MS sheet of the gas holder. Moreover, in the fixed-dome plants both liquid and solid materials are charged; but in the floating-dome plants, materials in the fluid form only can be utilized.

Fixed-dome plants are being built in rural and urban areas of the country, the raw materials being cow-dung, poultry dropping, human excreta, household garbage, etc. Training courses (two-week long) are given by the IFRD on the construction, operation and maintenance of the models. Over 1000 personnel have so far been trained.

Institutions Involved in Biogas

The following agencies have been involved in the introduction of biogas plants.

- Agricultural Chemistry Department of Bangladesh Agricultural University (BAU)
- Institute of Fuel Research & Development (IFRD) of Bangladesh Council of Scientific & industrial Research (BCSIR)
- Department of Environment (DOE)
- Bangladesh Small & Cottage Industries Corporation (BSCIC).
- Danish International Development Agency (DANIDA)
- Local Govt. Engineering Department (LGED)
- Department of Livestock (DLS)
- Some NGOs

Under the "Fuel Saving Project of BCSIR," financed by GOB, the gas holder was supplied free of cost on condition that the owners would bear the cost of the digester and other accessories, which usually involved approximately half the total cost. Dissemination in one or more thanas was assigned to an NGO having organizational infrastructure in the thanas concerned. The NGO selected the artisans/interested persons in consultation with the thana authority and sent them to the IFRD for training. Persons trained in the institute were encouraged through payment of a lump sum of Tk. 200.00 for each plant installed to

motivate farmers for owning biogas plants. They helped set up biogas plants in the household premises of well-to-do farmers and provided technical back-up services. Under this project 154 local youths were trained and 161 biogas plants installed.

The IFRD of BCSIR in collaboration with Dhaka City Corporation built an experimental biogas plant of 85 M^3 digester volume in 1992 at Dholpur for treatment of city wastes. Charging of 52.5 tons of wastes produced 2000 cft biogas/day on the average over a period of two months and 40 tons of residue (biofertilizer) rich in plant nutrients. The residue had no odor (BCSIR & DCC, 1993).

BCSIR has recently completed a project with GOB grant of Tk. 68.9 million for installation of 5000 biogas plants – at least one plant in each Union of the country. One hundred twenty eight supervisors have been recruited for supervising construction, operation and maintenance of the biogas plants already installed and also those to be installed during the project period. So far, over 5000 biogas plants have been installed in the country.

Another project, under a GOB grant of Taka 342.5 million for setting up 20,000 plants is now in progress. Strategy is the same as that followed in the previous project except that, in addition to supervisors, interested entrepreneurs are engaged to bring market forces in it.

4.3 Solar Home Systems

Since solar energy is available everywhere, this new technology may serve as a great booster for rural electrification if it is acceptable to the consumers. This technology is being utilized in many countries to supply electricity in a decentralized mode. With a view to experimenting this new technology under the climato-socio-economic conditions of Bangladesh, REB has undertaken a project for the supply of solar electricity in some islands of the Meghna River in Narsingdi district.

This was a pilot project (62.5 kWp) based on a French financial grant of 6.4 million french franc (1.1 million US$). Foreign currency component of the project was provided as grant by the Govt. of France and the local currency of Tk. 27.0 million by GOB.

The main objective of the project was to demonstrate the usefulness and techno-economic viability of PV systems under the climato-socio-economic conditions of remote and isolated areas where grid electricity will not reach in the near future. Another objective of the project was to study the effect of this new technology on the socio-economic upliftment of the consumers.

Under the overall supervision and guidance of REB, Narsingdi PBS-1 (NPBS-1) has been given the responsibility of operation, maintenance and bill collection. To help REB in site selection, specification of materials and training of users, BCAS and one French Firm viz. FONDEM have been appointed as consultants. Responsibility for supply of materials for the PV systems and the installation thereof lay with the French Firm, APEX and the local firm Associated Resources Management Company (ARMCO). Five types of PV-systems were delivered to 795 consumers as shown in Table 11.

The tariff structure (Table 12) for different PV systems has been fixed up. In fixing up this structure, the views of REB, PBS and local and foreign consultants have been taken into consideration. REB and PBS have a long experience of consumer acceptability vis-à-vis system viability of electricity supply.

Table 12. PV Systems in the REB Pilot Project

Type	System I Lantern	System II	System III	System IV	System V
No. of Consumers	115	367	37	146	129
Module (Watt peak)	6	Charged at PV charging station	Charged at PV Charging station	46	2x46
Battery (no. x volts	6V x 3.2	12V x 60 AH	2x12V x 60 AH.	12Vx100	2x12V x 100

x amp-hours)	AH			AH	AH
8 W fluorescent	1	2	2	2	1
3 W fluorescent	1	-	-	-	-
13 W fluorescent	-	-	1	1	2
Fan	-	-	1	1	1
Socket	-	1	1	1	1
CIF Cost (US$)	93	580	1107	750	1228

Table 13. Tariff Structure

Sl #	System	Security Deposit (Tk.)	Rate/Month (Tk.)
1.	System-I (Lantern + Module)	250/-	50/-
2.	System-II 2 lamps (8W) +1 socket +1 battery (60AH)	500/-	100/-
3.	System-III 2 lamps (8W) + 1 lamp (13W) + 1 small fan + 1 socket + 2 batteries (60AH)	1000/-	160/-
4.	System-IV 1 Module (46W) + 2 lamps (8W) + 1 lamp (13W) + 1 small fan + 1 socket + 1 battery (100 AH)	2500/-	175/-
5.	System-V 2 Modules (46W) + 1 lamp (8W) + 2 lamps (13W) + 1 ceiling fan + 1 socket + 2 batteries (100 AH)	3500/-	210/-

Battery charging station at Karimpur has been in operation since 2 January 1997. This station consisting of 320 modules of 46 Wp has the capacity of charging 160 12-V batteries simultaneously. Solar Charging Stations at Natun Bazar and also at Alipur, each with just half the capacity of Karimpur Station, have been handed over to REB/NPBS-1 on 03-02-97, and 06-03-97 respectively. Opinion polls conducted by BCAS indicate that consumers like system II and V more than system I, III and IV. Reasons, as expressed by the users, are:

(i) Recipients of systems II and III get their batteries charged in a day from the charging stations and use it for 5-7 days before the next charging. Charging fee of Tk.2/- per charge is applicable only in case of excess of 10 charges per month. However, they consider transport of battery to and from the charging station sort of hazardous and a kind of drudgery. That is why system III involving 2 batteries did not get popular.

(ii) System V with 2 modules of 46 Wp each and 2 batteries of 100 AH each is capable of running the allotted appliances (Tables 12 & 13) for the expected periods of time excepting rainy season. During the rainy season, daily solar installation was not enough to meet the need.

(iii) In cases of systems I and IV, duration of operation of the allotted appliances is much less than expected because of unpredictable solar isolation especially during the rainy season.

Experiments carried out in BCAS and ARMCO show that charging rate to the 6V 3.2 AH battery from the 6 Wp panel is too low to be of practical use and battery condition deteriorates rather quickly after successive charging and discharging.

Organizations engaged in solar PV activities are the following.

- Associate Resource Management Co (ARMCO)
- Atomic Energy Commission (AEC)
- Bangladesh Centre for Advanced Studies (BCAS)
- Bangladesh Council of Scientific Industrial Research (BCSIR)
- Bangladesh University of Engineering and Technology (BUET)
- Centre for Mass Education in Science (CMES)
- Dhaka University
- Grameen Shakti
- Local Government Energy Department (LGED)
- Ministry of Energy and Mineral Resources (MEMR)
- Power Cell
- Bangladesh Power Development Board (BPDB)
- Rahim Afrooz
- Rural Electrification Board
- Siemens (Bangladesh)

4.4 Lessons Learnt on Applications of Renewable Energy Technologies

A survey conducted one year after the completion of the 62.5kWp project revealed the following facts:

(i) Cost in respect of construction, repairing and maintenance is the most dominant factor, but not the only factor, for sustainability of renewable energy technologies.

(ii) Saving fuel or achieving cleaner environment by using improved stoves do not make much appeal to those poor families who find it difficult to make both ends meet. That means the supply should be demand-based.

(iii) Improved stoves are easily acceptable to those who buy biomass fuels for cooking and other purposes. This shows that demonstration of the technologies is a necessity.

(iv) Technologies must be made according to specifications and technical back-up service in respect of the availability of spare parts and trained manpower must be ensured.

(v) Demand for use of biogas for the purpose power generation is on the increase.

(vi) Solar home systems (SHS) are liked by rural families, because SHS improves the quality of life significantly. The current high cost and low reliability because of unpredictable solar insolation stand in the way of its widespread use. Solar-wind-diesel hybrid will solve this problem.

(vii) Once a family gets used to a better quality of life through a new technology, it wishes to maintain it. It is, therefore, important that, for the desired improvement, the group be exposed to the new technology till it gets used to the technology. Once this happens, commercialization and attendant entrepreneurial development will take place automatically.

But to achieve this, initial cost and price of spare parts must be within their reach. International help and government regulations in prospect of tax incentive and subsidy may be an appropriate booster.

4.5 Need for Capacity Building

(i) Above review shows that Bangladesh has adequate expertise and institutional capacity for efficient stoves and biogas technologies.

(ii) For solar PV systems, institutions are growing rapidly for the manufacture of balance of system (BOS, items other than PV module) and the installation and operation thereof, but the local manufacture of PV module is yet to start.

(iii) Only three GEF projects are on record—one of them is currently under implementation. Projects under CDM are yet to start. Expertise on GEF and CDM projects are being developed in some NGOs including BCAS. Further capacity building in GFF and CDM will help expedite the preparation of bankable projects.

(iv) Formation of Renewable Energy Development Agency (REDA) is currently under consideration of GOB. REDA will have the mandate to take necessary steps for development, promotion and utilization of renewable sources of energy.

(v) Energy Audit Cell (EAC) under MEMR, responsible for energy efficiency studies in industries and power generation plants, are not adequately equipped in respect of manpower and equipment. Further strengthening of this cell is immediately needed.

(vi) Although PBSs under REB are given the responsibility of introducing solar PV systems in the rural areas, they need trained personnel dedicated to the solar systems alone. Persons appointed for both grid and off-grid options do not get interest in the latter.

(vii) Overall, technical expertise is adequate in improved stoves and biogas technologies, and some expertise in solar systems. There is practically no expertise in other RETs and EE fields. A severe lack of capacity in government, non-government, private and financial sectors to appreciate, plan and finance RE and EE projects is a big barrier to RE development EE improvement.

4.6 Women and Renewable Energy

4.6.1 Background

The main feature of women situation in Bangladesh is the combination of roles that they have to carry out for household management. These include income earning, cost-saving, cooking foodstuffs, processing agricultural produces and caring/nurturing of children. Women are differentially placed in the society according to their education, income, land-holding pattern and social and family organization, etc. There are a number of inherent problems in addressing women's needs. For any developmental intervention, it is difficult to reach women effectively, especially those who are poor and uneducated.

The Ministry of Women and Children Affairs, GOB, has undertaken the following programs for the development of women.

(i) Intervention for reducing drudgery
(ii) Addressing gender issues at the work place
(iii) Supportive environment for women's employment
(iv) Support for women's roles in household and field production
(v) Education to women
(vi) Highlighting reproductive health issues of women
(vii) Addressing problems of women's access to water and sanitation.

In the Fourth Five Year Plan (1990-1995) a sum of Tk. 880 million was earmarked for development of women. Programmes include (a) Training of women in poultry, dairy, food processing and other non-traditional fields, (b) Providing loan for self-employment, (c) Poverty alleviation through food for work and providing job opportunities, (d) Providing accommodation for job seeking and employed women, (e) Day-Care Centre for children of working women, (f) Giving legal protection to the oppressed women.

A major thrust of the Fifth Plan (FFYP, 1997) is on developing the skills of women with the aim at yielding substantial increase in productivity of existing women labor force and opening up new windows of opportunities for future entry into the labor force. For the welfare and rehabilitation of destitute women there is a fund at the disposal of the Prime Minister. This special welfare fund is utilized for distribution as loan among the destitute women for income earning activities.

4.6.2 Women and Renewable Energy Technologies

In Bangladesh, cooking and household processing of agricultural produces such as parboiling of paddy, evaporation of date palm juice; cane-sugar juice, etc. are the responsibilities of women. They have to collect fuel and for this purpose by walking long distances and waste most the their working hours. Cooking/processing of agricultural products in traditional stoves is a real drudgery and wastage of biomass wealth. Because of exposure to the harmful gases from the stoves, most of the women suffer from lung and eye diseases at old age. Improved stoves have come to them as a great relief. So far, over 2,500 women have been trained on the construction, operation and maintenance of improved stoves. These women build stoves for their own families and also help make stoves for others on receipt of some fees. Many of these trained women have undertaken stove building as an income generating activity.

Other technologies that are being introduced to reduce drudgery of women are: (a) biogas, (b) SHS, (c) solar cooker, and (d) solar dryer.

5. POLICY & INSTITUTIONAL FEATURES IMPACTING REGA TECHNOLOGY DISSEMINATION

5.1 Renewable Energy and Power Sector

Access to electricity in Bangladesh is one of the lowest in the world. Coverage today stands at less than 20% of the total population. However, the rural areas of Bangladesh, where 76% of the population live, are seriously deprived of the electricity facility. Larger energy supplies and greater efficiency of energy use are thus necessary to meet the basic needs of a growing population. It will, therefore, be necessary to tap different sources of renewable energy resources, which are available considering economic & technical viability and keeping in view the Environmental Quality Standard (EQS). Plant location, size and design will be considered on the basis of available energy resources of the area and efficient conversion of energy will be given preference. Priority will be given to the rural areas where national grid expansion is expensive. This will reduce the pressure on the demand of commercial power supply and will help avoid costly grid expansion and keep environment pollution- free.

Private capital investment for implementing RE is a major issue to be considered. The policy envisages accomplishment of its objectives by mobilizing a concerted national effort with the continued cooperation and commitment of government, international organizations, bilateral and multilateral funding institutions, nongovernmental organizations, research organizations, universities, etc. It has become increasingly clear that for the development of RE, the funding windows of non-government and private sources as well as financial and development institutions should be augmented. Furthermore, innovative new financing opportunities including micro financing may be utilized to attract private capital to supplement the energy deficiencies in the rural areas and thus to fulfill the aspiration of the poor people.

Compared with conventional energy it is found that RE is not yet a cost-effective technology. But the technology is advancing rapidly. In consideration of giving benefit to the rural areas as a commitment and social objective, GOB formulated new policies for RE development and dissemination. The “National Energy Policy, 1996” of Bangladesh envisages sustainable development of RE sources.

5.2 Government Policy and the Power Cell

In order to translate these policy objectives into actual investment projects, GOB has taken keen interest to finalize and declare an RE policy. Under the proposed Electricity Reform Act (ERA), there is also provision to regulate the development & operation of RE. Until Energy Regulatory Commission (ERC) is formed under the proposed ERA, Power Cell will carry out all primary and initial work related to development of RE.

5.3 Modality for Implementation of Renewable Energy Projects

5.3.1 National Energy Policy (NEP) 1996 Covering Renewable Energy

National Energy Policy, 1996 has been updated recently. The final updated version (MEMR, 2002) is awaiting GOB approval. The Power Cell will articulate and co-ordinate in implementing the RE projects and will assist the Board of Investment (BOI) to promote and facilitate foreign and local investment in this sector. The Cell would represent government interest in RE projects.

5.3.2 Renewable Energy and Power Cell

The Power Cell/ERC will undertake the following functions.

(i) Assist in issuance of license for RE projects sponsored by private entrepreneurs in a localized area.
(ii) Identify and assess the potential of establishment of RE projects, which could make a significant contribution to energy needs both in short and long term.
(iii) Recommend financing and delivery mechanism to increase the affordability of RE systems for the rural poor.
(iv) Encourage NGOs and private sector organizations in the development of RE and suggest strengthening the institutional requirements for successful implementation of these projects.

(v) Recommend required training facilities for technology transfer needed to support commercialization of RETs.
(vi) Identify the type and extent of support needed from international organizations.
(vii) Consider existing infrastructure and future plan of different utilities before issuance of licenses for establishment of RE projects.

5.3.3 Financing Arrangements

(i) GOB is a signatory to the UNFCCC. It may establish a Global Environment Facility (GEF) grant fund to support RE projects in Bangladesh.
(ii) GOB may allocate funds to a few designated banks for financing the capital costs of RE projects.
(iii) To facilitate the creation and encouragement of a corporate debt securities market that is essential for raising local financing for RE projects, the following will be allowed:

(a) Permission for RE project companies to issue Corporate Bonds with the consent of the Securities and Exchange Commission (SEC).
(b) Permission to issue shares at discounted prices up to the limit of 10% of the face value to enable venture capitalists to be provided higher rates of return proportionate to the risks.
(c) Permission to foreign banks to underwrite the issue of shares and bonds by the private power companies with the recognition by SEC of such underwriting.
(d) Tax facilities for private sector instruments as available to non-banking financial institutions.

Source: MEMR (2002).

5.3.5 Environmental Impact Assessment (EIA)

It would be absolutely necessary to carry out Environmental Impact Assessment (EIA) to establish any RE project and clearance from the Department of Environmental would also be needed. The project proponent must follow “Bangladesh Environmental Conservation Act ’95” and “Environmental Conservation Rules ’97”.

5.4 Tariff for Sale of Power

5.4.1 Power Offtake

It would be the responsibility of the sponsor to find customers for electricity. Sponsors would have direct contract with the customers for the sale of electricity on terms mutually agreed upon. The sponsors themselves may build the distribution system required for supply of electricity to the contracted customers or they can use the existing transmission and distribution systems, if there is adequate capacity. The sponsor would be required to pay a wheeling charge to the owner of transmission/distribution facilities. The wheeling charge and other terms and conditions will be mutually agreed upon between the sponsor and the owner of the transmission/distribution facilities.

5.4.2 Price Regulation

In areas covered by BPDB/DESA/REB, the tariff announced by GOB from time to time shall apply. In other areas GOB does not regulate the price of electricity, which shall be negotiated between the sponsor and the consumers. At present, Ministry of Energy and Mineral Resources (MEMR), GOB, regulates the price. Energy Regulatory Commission (ERC), when formed under the proposed Electricity Reform Act, will take over these activities.

5.5 Fiscal Incentives

- RE project sponsor--semi-government, private companies (foreign or local), NGOs--shall be exempt for corporate income tax for a period of 15 years.
- 100% depreciation in the first year for solar photovoltaic, solar thermal project and 100% depreciation in five years for wind, biomass, geo-thermal and small hydro project.
- The sponsor will be allowed to import plants and equipments without payment of customs duties, VAT (Value Added Tax) and any other surcharges as well as import permit fee except for indigenously produced equipment
- Repatriation of equity along with dividends will be allowed freely.
- Exemption from income tax in Bangladesh for foreign lenders to such companies.
- The foreign investors will be free to enter into joint ventures.
- The companies will be exempted from the requirements of obtaining insurance/reinsurance only from the National Insurance Company, namely Sadharan Bima Corporation (SBC).

Source: MEMR (2002).

- The Instruments and Deeds required to be registered under local regulations will be exempted from stamp duty payment.
- Power generation has been declared as an industry and the companies are eligible for all other concessions, which are available to industrial projects.
- The private parties may raise local and foreign finance in accordance with regulations applicable to industrial projects as defined by the Board of Investment (BOI).
- Local engineering and manufacturing companies shall be encouraged to provide indigenously manufactured equipment of international standard to renewable energy project sponsors.

5.6 Other Facilities and Incentives for Foreign Investors

The following facilities and incentives would be provided to foreign sponsors:

- Tax exemption on royalties, technical know how and technical assistance fees and facilities for their repatriation.
- Tax exemption on interest on foreign loans.
- Tax exemption on capital gains from transfer of shares by the investing company.
- Avoidance of double taxation in case of foreign investors on the basis of bilateral agreements.
- Exemption of income tax for upto three years for the expatriate personnel employed under the approved industry.
- Remittance of upto 50% of salary of the foreigners employed in Bangladesh and facilities for repatriation of their savings and retirement benefits at the time of their return.
- No restrictions on issuance of work permits to project related foreign nationals and employees.
- Facilities for repatriation of invested capital, profits and dividends.
- TAKA, the national currency, would be convertible for international payments in current account.
- Re-investment of remittable dividend to be treated as new foreign investment.
- Foreign owned companies duly registered in Bangladesh will be on the same footing as locally owned companies with regard to borrowing facilities.

Source: MEMR (2002).

6. SUSTAINABLE DEVELOPMENT PRIORITIES IN BANGLADESH

6.1 National Environmental Management Action Plan (NEMAP)

NEMAP was carried out in the early nineties to provide a framework for integrating environmental consideration into economic and social development. The NEMAP process ensured the representation of all socio-economic groups under a bottom-up participatory planning approach covering all the regions of the country. The exercise led to the identification of environmental problems, their causes and solutions through concrete actions at local, regional and national levels across different economic and social sectors.

6.2 Sustainable Environment Management Project (SEMP)

The focus of SEMP is on policy and institutions, participatory ecosystem management, community based environmental sanitation, awareness and advocacy and training and education. SEMP is being implemented by 22 agencies or organizations of which 13 are civil society bodies and NGOs having good track record of successful programmes at the grass-roots level.

6.3 Sustainable Development under the Fifth Five Year Plan (1997-2002)

The emphasis of the Fifth Five Year Plan (FFYP, 1997) is to promote, nurture, protect and expand nature and natural resources and link all developmental activities with environment towards improving the quality of life. Following are the environmental goals and objectives of the FFYP.

(i) Promote sustainable environment management in pursuit of quality livelihood and alleviation of poverty.
(ii) Promote participatory, community-based environmental resource management and environmental protection.
(iii) Ensure active participation of the poor, especially women, in environment protection activities.
(iv) Promote environment-friendly activities in development interventions.
(v) Preserve, protecting, and developing the natural resource base.
(vi) Strengthen the capabilities of public and private sector to address environmental concerns.
(vii) Control and prevent environmental pollution and degradation related to soil, water and air.
(viii) Create public awareness for participation in environment promotion activities.
(viii) Conserve non-renewable resources and sustaining auto-and eco-generation of renewable resources.

In order to achieve the objectives and goals of environment and sustainable livelihood, the FFYP, have the following strategies, inter alia.

(i) The Executive Committee of the National Environment Council headed by the Prime Minister will be activated.
(ii) Environment Committees at District and Thana levels with people's participation will be formed and activated.
(ii) Ministry of Environment and Forest will be strengthened.
(iv) Sectoral legislations will be redrafted in the light of Bangladesh's commitment expressed through signing and ratifying a number international conventions and protocols on environment.
(v) "Polluters Pay Principle" will be followed.

(vi) "National Environmental Fund' will be established in order to provide assistance to the victims of environmental degradation due to natural disasters and anthropogenic activities.

(vii) Incentives, in the form of tax rebate, tax holiday, will be provided and incremental cost incurred by the environment friendly entrepreneurs will be met in various forms/sources.

The FFYP has recognized the importance of multidisciplinary approach to deal with environmental concerns since poverty, environment, energy and sustainable livelihood interact in a complex way.

6.4 Sustainable Human Development (SHD) Model

GOB has recently established a SHD unit in the Planning Commission. As per its functions, the SHD unit is expected to provide the quantitative analysis required for the formulation of the Sixth Five Year Plan. The Institute of Social Studies in The Hague and Swedish International Services in Stockholm provide technical backup to the SHD unit.

6.5 Valuation of Natural Resource Degradation

A number of studies have been carried out to assess the extent of natural resource degradation and the losses to the national economy due to such degradation. These studies have dealt with the state of environment and natural resource degradation involving land, water, forestry, fisheries, biodiversity in the context of sustainable development (Report of the Task Forces, Vol. IV, 1990).

Bangladesh Bureau of Statistics (BBS, 1999) has developed a framework to generate environmental statistics, which would make valuable contribution in planning required for sustainable development.

6.6 Planning for Poverty Alleviation

Poverty alleviation planning in a developing country like Bangladesh must aim at developing rural areas where 76.4% of the population live (BBS, 2001). There are inter-relationships between energy and food, energy and environment, and energy and agriculture. Successful implementation of the development programs be it women development or youth development – are dependent on sustainable energy supply. The realization has now dawned on the developing countries that the centralized system of fossil fuel supply has not contributed much to the rural development. Moreover, burning of fossil fuels is increasingly polluting global environment leading to many serious consequences (GEO-3, 2002). What is the alternative then? Obviously, the alternative is the natural renewable sources of energy, which are locally available, right in the rural areas themselves.

Fortunately, Bangladesh has abundant supply of renewable sources of energy. Electricity supply is the key to all kinds of development. As seen in Table 8, the country has a potential of 53,108 MW from solar, wind and hydro resources alone. If 10% of this potential is harnessed, it will mean 132% of the present capacity. RETs aim at energisation of which electrification is just one component. GOB is providing special incentives for development of RETs. NGOs and private organizations (Grameen Shakti, BRAC) are disseminating RETs through micro credits.

The dispersed nature of rural households and the difficult access due to innumerable rivers and canals make the grid electrification difficult and expensive. Moreover, a large number of households use less than 40 kWh a month. In order to increase the rate of electrification and reduce the cost of access and supply, GOB is planning to supplement grid-based electrification with off-grid options.

Policies for poverty alleviation have been a part of several macroeconomic policies and in particular, of those associated with the targeted public expenditure programme (Shamunnay, 2000). The Annual Development Programmes finance a good number of projects in agriculture, rural development and social sector to alleviate poverty. The major public expenditure programmes aiming at poverty

alleviation include (a) Test Relief, (b) Food for Works Programme, (c) Vulnerable Group Development Programme, (d) Rural Development, (e) Women Development, (f) Youth Development, and (g) Food for Education. Besides, there are other programmes, which indirectly impact on poverty alleviation. Bangladesh Rural Development Board (BRDB) and Palli Karma Shahayak Foundation (PKSF) are two GOB approved organizations engaged in poverty alleviation through providing micro-credits to the poor.

Empowering rural people and especially rural women in rural development project is the best way of alleviating poverty. Introduction of RE and GHG abatement technologies is one of way empowering them through augmenting income generation opportunities and reducing vulnerability to diseases and thus improving quality of life (Biswas et al. 2001).

A large number of NGOs are engaged in socioeconomic upliftment of the poor through social mobilization. Among the NGOs, the major ones are the Grameen Bank, BRAC, PROSHIKA, ASA, RDRS, GSS, which operate massive micro credit facilities to the beneficiary members to purchase RETs. The micro-credit programme of the NGOs is large compared to that of the government in financial terms. A number of commercial banks also participate in poverty alleviation programmes through providing micro-credit to the landless and small farmers.

Bangladesh has been a key partner of a number of international declarations and summits on poverty alleviation and social development of the poor. These include the Dhaka Declaration for poverty eradication during the SAARC summit meeting in 1993, the Social Summit of Copenhagen in 1995 and the World Micro Credit Summit in Washington in 1997.

In the light of past experience and commitment of the GOB to poverty alleviation, the FFYP adopts a pro-poor strategy to accelerate the pace of poverty eradication. Human resource development and generation of gainful employment have been given priority under the FFYP. The plan envisages to substantially increasing budgetary allocation for the social sector including energy supply, education, and health, drinking water supply, sanitation, and family welfare, women and youth development. Along with general education, there has been greater emphasis on skill development through technical education under the existing pro-poor projects of the government and NGOs.

The major donor agencies are also shifting their policies toward poverty alleviation and protection of environment. The United Nations Development Programme (UNDP) attaches high priority on poverty reduction through community empowerment, non-formal employment generation, and women in development, improved environmental management and improved public management.

Consistent with the government's development strategy, the Asian Development Bank's Medium-Term Strategic objective in Bangladesh is geared to poverty reduction through faster economic growth, creation of better development opportunities for the poor, improvement of human development and environmental protection (ADB, 1999). There has been pro-poor compositional shift in ADB's lending over the years. The share of education, road, transport, and communication in total lending has been marked by significant increase over the years in view of the strong poverty alleviating impact of investment in human capital and physical infrastructure.

6.7 National Energy Priorities in the Fifth-Five-Year Plan (FFYP, 1997)

a. Provide energy for sustainable economic growth so that the economic development activities of different sectors are not constrained due to shortage of energy.
b. Meet the energy needs of different zones of the country and socio-economic groups.
c. Ensure optimum development of all the indigenous energy sources.
d. Ensure sustainable operation of the energy utilities.
e. Ensure rational use of total energy sources.
f. Ensure environmentally sound sustainable energy development programs causing minimum damage to environment.

g. Encourage public and private sector participation in the development and management of the energy sector.

6.8 Strategies in Respect of Renewable Energy (FFYP, 1997)

a. Dissemination of various forms of RE technologies like solar, wind and mini-hydro especially in rural areas and other remote and isolated locations of the country.

b. Biogas technology is believed to have good potential as source of energy in Bangladesh. The BCSIR has developed technologies though their dissemination has been very limited. During this Five Year Plan, efforts are being made to popularize the use of biogas technology in the country.

c. Replacement of traditional stoves by an improved version with better energy conversion efficiency will help conserve biomass in the rural areas. Moreover, use of the technology in urban areas will help reduce consumption of fuel wood, thereby reducing deforestation. Technologies are available and efforts are being made to popularize them during the current Five Year Plan.

d. Application of new and RE technologies.

e. Making appropriate institutional, fiscal, legal and administrative arrangement for successful implementation of the above strategies.

Good RE potential coupled with the above strategies of GOB are expected to usher in a new era of RE development and utilization in Bangladesh.

6.9 Government Policy on GHG Mitigation

GOB has also initiated several policy actions, which support activities under the UNFCCC, reduction of GHGs and considerations on adaptation. Many of the key policies and actions are focused towards the sustainable development goals. Energy sector policy has emphasized the role of renewable energy. GOB in cooperation with NGOs has already established a solar village with 795 households electrified by Solar PV. Many other NGOs and private sectors are increasingly promoting the renewable energy technologies in the country.

In addition to being sources of GHG, forest and forestland are important sinks or reservoirs of carbon. They have received adequate attention in the national development plan. A large part of natural forest of the country that is set aside for conservation and productivity will be increased through creation of tree plantation with public participation as far as applicable. A total of 32,000 hectares agro-forest and woodlot plantation and 25,000 kilometers strip plantation were planned to be raised by 2002.

In Bangladesh, tree plantation has become a major annual event and festival involving government, NGOs and local communities. This is adding significantly to carbon sequestration potential as well as supply of nutrition for the rural poor by providing fruits.

In April 2001, GOB has also setup a “Working Committee” for appropriate implementation of activities related to the UNFCCC. The government needs to setup new institutions and strengthen existing institutes to deal with climate change and sustainable development issues.

7. IDENTIFICATION AND PRIORITIZATION OF REGA TECHNOLOGIES FOR PROJECT PREPARATION

From the review of renewable energy, energy efficiency and GHG emission status and the current government policies given in the Chapters that follow, nine projects have been identified and recommended (in order of decreasing priority) to be developed into pre-feasibility studies under the PREGA project.

(i) Waste to electrical energy project
(2) Introduction of co-generation in sugar industries
(3) Solar-wind-diesel hybrid for power generation for small towns and villages
(4) Fuel switching from oil to gas for power generation
(5) Energy efficiency studies in industries
(6) Rehabilitation of electricity distribution network
(7) Combined cycle power plant in place of gas-steam power
(9) Conversion of gasoline cars to CNG cars
(9) Replacement of 2-stroke engines with 4-stroke engines for auto rickshaws

Details of these projects will be given in the pre-feasibility reports. Key information for prioritizing the above projects is discussed below. From the presentations and discussions, it can be seen that issue-related barriers are: (i) technological, (ii) financial, (iii) institutional, and (iv) policy related. Details of barriers specific to projects and strategies will likewise be discussed in each of the pre-feasibility report.

7.1 Waste to Electrical Energy

A large amount of wastes is generated daily in the city of Dhaka. Power Cell, Ministry of Energy and Mineral Resources (MEMR), under the sponsorship of the World Bank, commissioned Bangladesh Centre for Advanced Studies (BCAS) in 1998 for quantity assessment and Institute of Fuel Research and Development (IFRD) of BCSIR for quality assessment of the city wastes. According to quantity assessment (BCAS, 1998), this city generated about 5000 tons of wastes daily in 2002 and the daily generation would increase to over 15,000 tons in 2025. This nuisance can be transformed into a resource if it can be processed to generate electricity.

Several technologies for the conversion of Municipal Solid Wastes to Electrical Energy (MSWEE) are now available worldwide. These include (a) Landfill, (b) Mass Burn Incinerator (MBI), (c) Fluidized Bed Incinerator (FBI), (d) Gasification, and (e) Plasma Converter (Yang and Lee, 2002). In 1998, GOB (Power Cell, MEMR) invited firms to submit pre-qualification statements for MSWEE project. Six international companies submitted statements. As two of these firms did not meet the basic bidding criteria and they were dropped.

On invitation from the National Implementation Committee (NIC) of PREGA, an ADB Mission comprising visited Dhaka in October-November 2002 to review the different technologies, evaluate the technical proposals submitted by different firms and recommend appropriate technology for MSWEE project in Dhaka. The ADB Mission reviewed the results of quantity (BCAS, 1998) and quality (IFRD, 1998) assessments. The results are given in Tables 13 and 14.

Table 14. Projection of Waste Generation in Dhaka

Year	Wastes (kilo tones/day)	Wastes (million tonnes/yr)
2002	5.35	1.95
2003	5.65	2.06
2004	5.97	2.18
2005	6.30	2.30
2006	6.66	2.43
2007	7.03	2.57

2008	7.43	2.71
2009	7.84	2.86
2010	8.28	3.02
2011	8.75	3.19
2012	9.24	3.37
2013	9.76	3.56
2014	10.31	3.76
2015	10.89	3.97
2016	11.50	4.20
2017	12.15	4.43
2018	12.83	4.68
2019	13.55	4.95
2020	14.31	5.22
2021	15.11	5.52

Source: BCAS (1998).

Table 15. Ultimate Analysis Results of the Solid Wastes of Dhaka

Contents	Share by weight		Calorific Values	Btu/lb	Kcal/kg
Water (moisture)	50%-70%		As received	1386-2600	770-1444
Carbon	6.02%-26.06%		Air dry (with moisture 5-8%)	2900-4300	1611-2389
Hydrogen	1.20%-3.53%		Oven dry	3200-6200	1833-3444

Source: IFRD (1998) and the Mission's calculation

Although daily generation is large (5,350 tonnes in 2002 and projected to rise to 15,110 tonnes in 2021), water content is rather high (50-70%). The ADB Mission, reviewing the state-of-the-art technologies that are available and analyzing the quantity and quality of wastes, recommends that landfill technology is the best choice for Dhaka city wastes.

This project deserves topmost priority for immediate pre-feasibility study due to the following reasons:

(i) Daily generation is large indicating feasibility of a 30 MW plant.
(ii) The present method of dumping in open fields generates a lot of GHG including large amount of CH_4. MSWEE therefore holds high promise for CDM-ability.
(iii) GOB has already taken initiative to implement the project.

7.2 Introduction of Cogeneration

As earlier stated, there are 17 sugar industries in Bangladesh processing about $7x10^6$ tonnes of sugar canes annually (GOB, 2001). The biomass produced during crushing is used for power generation. There are scopes for increasing the efficiency of power generation on one hand and better utilization of waste heat from the power plants on the other.

Sugarcanes crushed in the mills produce 34-36% biomass called bagasse, which has a calorific value of about 2,300 Kcal/Kg making it an attractive energy source. Hence, bagasse is burnt in the mill boilers to produce steam for generation of electricity and also for using it as process heat. Cogeneration is being practiced in all the sugar industries of the country; but the utilization is far below the full potential as seen below:

(i) On the average, 19 Kgs of bagasse are burnt to generate one kWh of electricity.

(ii) On the average, 41 Kgs of steam are consumed to generate one kWh of electricity. With efficient cogeneration facilities, 5-6 Kgs of steam are normally needed for one kWh.

(iii) Turbine exhaust heat is not enough to meet the requirement of process heat and as such direct steam from boilers is used as process heat.

(iv) This low efficiency is due to low steam pressure (10-29 Kg/cm^2) and low steam temperature (222-35^OC). To derive full benefits of cogeneration, operation at 65 Kg/cm^2 pressure and 480^OC is needed.

(v) The sugar industries purchase over 12,000 MWh of electricity annually from the BPDB.

(vi) Some plants are more than 3 decades old and they do not permit full utilization of cogeneration.

GOB is keen on increasing the efficiency of the industries to reduce the cost of sugar production and emission of GHGs. The expected benefits include the following.

a) Ten times of present electricity production is possible with appropriate design. Excess electricity will be sold to the grid thus lowering the cost of production.

b) More financial benefits can be given to the farmers for selling sugarcane to the mills instead of using them for "Gur" (unrefined home-made sugar).

In addition to sugar industries, there is a big potential of saving 3.15 PJ annually in cogeneration of other industries (Table 6). In respect of both efficiency increase and GHG abatement, co-generation is recommended as a priority project for pre-feasibility studies after MSWEE.

7.3 Solar-Wind-Diesel Hybrid

As shown in Table 15, Bangladesh has a good supply of solar energy.

Table 16. Monthly Averages of Daily Insolation (kWh/m^2) and Yearly Insolation Availability (MWh/m^2) on a Horizontal and Tilted Surface at Dhaka (Latitude 23°-45′ N, Longitude 90°-20′ E)

Month	Horizontal surface	Tilted surface (30^0)
January	4.03	5.52
February	4.78	5.93
March	5.33	5.76
April	5.71	5.42
May	5.71	5.02
June	4.80	4.20
July	4.41	3.89
August	4.82	4.43
September	4.41	4.45
October	4.61	5.35
November	4.27	5.77
December	3.92	5.57
Yearly Total (MWh/m^2)	1.73	1.86

Daily average on a horizontal surface = 4.74 kWh.
Daily average on a titled surface (30^0) = 5.09 kWh

Results shown in Table 16 lead to an annual average solar insolation of 1900 kWh/m^2. Installation of Solar PV systems is making steady progress in the rural areas where grid electricity will not reach in near future. Under a French financial grant of 1.1 million US$ and GOB grant of Taka 27 million, solar home systems (SHS) were given to 795 houses. Post-installation survey in 2000 conducted by BCAS (GOB, 2000) sponsored by GOB showed that solar PV improved the quality of life, enhanced children's education facilities and improved shopping systems in rural market places; but during the rainy season, solar insolation was not high enough to meet the demand. This makes the solar PV systems unreliable in the rainy season and leads to dissatisfaction of the users. In order to eliminate this uncertainty, some hybrid using other sources of energy is needed.

Correct wind mapping is not available. Wind data obtained by BAEC (5-7 m/sec, annual average) do not tally with those obtained by Meteorological Department (2-4 m/sec, annual average). Under a grant from DFID, BCAS in collaboration with LGED and ETSU (UK) made a systematic wind speed study at 7 coastal locations at a height of 25 m in 1996-97. Wind speed shows strong seasonal variation (Table 17).

Table 17. Monthly Average Wind Speed (m/sec) in the Coastal Region of Bangladesh (July 1996 - September 1997)

Coastal Location	Average Wind Speed (m/sec) during	
	April - August	September – March
Patenga	5.06	3.24
Cox's Bazar	4.33	2.73
Kutubdia	5.08	3.58
Teknaf	3.86	2.32
Noakhali	4.11	2.09
Kuakata	6.35	3.24
Charfassion	4.94	3.17

Source: BCAS (1998).

Since the wind speed is higher (2.81-6.35 m/sec) during the rainy season than in winter (2.09-3.58 m/sec), a solar-wind hybrid for Bangladesh looks feasible. However, diesel should also be included in the hybrid system to make the system 100% reliable. Grid electricity users experience outages a number of times without notice every day. In the proposed hybrid system, there will be no such outage. Only 10% of the village population has access to electricity. Viability of the system will pave the way for rapid expansion of rural electrification. GOB attaches priority to this type of project and has reduced import duty on wind turbine from 30% to 2.5%. No tax is levied on solar equipment except those that are locally fabricated. This project is therefore recommended as a priority project for pre-feasibility study.

7.4 Fuel Switching from Oil to Gas for Power Generation

More than 12% total generation capacity (Section 2.3) is attributed to diesel and furnace oil. Oil-based power plants are shown in Table 18. Oil used in captive generation is also quite significant causing drainage of the country's foreign exchange and worsening pollution because of low efficiency and high sulfur and ash contents in oil.

Table 18. Oil-based Power Generation (2000-2001)

Sl No.	Name of Power Plant	Installed Capacity (As of June) (MW)	Fuel Type	Gross Energy Generation (GWh)	Annual Plant factor (%)	Efficiency (%)
1.	Khulna 1x110 MW Steam Turbine	110	F. oil	8.89	0.92	22.78

	Khulna 1x60 MW Steam Turbine	60	F. oil	354.03	67.36	29.29
	Khulna 2x28 MW BMPP	56	SKO	25.45	5.19	28.82
2.	Bheramara 3x20 MW Gas turbine	60	HSD	80.35	15.29	21.07
3.	Thakurgaon 4x1,5 MW Diesel	6	LDO	1.65	3.14	31.37
4.	Saidpur 2x3.75 MW Diesel	3.75	F. oil	0.18	1.17	17.23
			LDO	0.21		23.79
	Saidpur 30 MW Gas turbine	20	HSD	32.38	18.48	21.99
5.	Barisal 2x20 MW Gas Turbine	40	HSD	54.27	15.49	22.99
	Barisal Diesel (9 units)	2.6	GSD	0.49	2.16	16.51
6.	Rangpur 20 MW Gas Turbine	20	HSD	21.19	12.10	25.49
7.	Bhola Diesel	6	HSD F. oil	3.46 4.51	15.16	24.56
8.	KPCL	110	F. oil	555.90		

Source: BPDB (2001).

Heavy furnace oil and high sulfur furnace oil used in the electricity generating plants emit a lot of sulphur dioxide. Moreover, high ash and high nitrogen in the oil enhance particulate and NO_X emissions. Adding precipitators, flue gas desulphurization plant and low NO_X burners, can reduce emissions but they will add to the cost of an already inefficient plant.

Natural gas in Bangladesh, being mostly methane and free of sulfur, may be an ideal substitute for oil to increase efficiency leading to reduction / elimination of GHG and SO_2 and particulate emissions. This project is also recommended for pre-feasibility study.

7.5 Energy Efficiency Studies in Industries

As seen in Table 7, there had been a potential of annual saving of over 16 PJ using efficient devices and proper housekeeping. Since this study is about 2 decades old, a fresh study is needed to find out more accurate potentials including specific industries. In the year 1983-1984, the total amount of commercial energy consumption in industries was 28.2 PJ (GOB, 1985). Another study carried out in 1993-1994 for seven factories also show scope for significant saving (21-31%). From the studies above, processes and devices, which hold promise for large savings and are also amenable to improvement, will be selected.

7.6 Rehabilitation of Electricity Distribution Network

In the People's Republic of China (PRC), a project on rehabilitation of rural distribution network of electricity was implemented during 1998-2001. Rehabilitation of electricity distribution network in PRC reportedly brought down the loss of electricity from 30% - 40% to 12% -13% (Yang, 2001). This project is obviously worth undertaking in Bangladesh.

7.7 Combined Cycle Power Plant in Place of Gas Steam Power

Combined cycle power plant is more efficient than gas steam power. This project is aimed at substituting old gas steam plant with gas combined cycle technology. This will help reduce both costs and GHG emissions that are easily monitored.

7.8 Conversion of Gasoline Cars to CNG Cars

There are over 420,000 liquid fuel-run vehicles in the country (GOB, 2001). GOB has been trying to popularize CNG cars over the last 10 years, but the progress is rather slow. In order to speed up the process, a project that will significantly reduce both operating cost and GHG emissions may be

undertaken under PREGA. Moreover, this will reduce the pollution of cities to a great extent. Monitoring of GHG reduction can be easily done.

7.9 Replacement of 2-Stroke Engines with 4-Stroke Engines for Auto-Rickshaws

There are over 89,000 two-stroke three wheelers (GOB, 2001) in the country. These 3-wheelers create nuisance in the city of Dhaka. Combustion is incomplete and mixing of lubricating oil with gasoline makes the emissions worse in respect of obnoxious gases and particulates leading to polluted air, especially during traffic jams. GOB has already taken steps in converting 2-stroke 3-wheelers to 4-stroke CNG 3-wheelers. This initiative, in which GHG reduction can be easily monitored, may be expanded, as there is still a large number of 2-stroke 3-wheelers in the country. GHG reduction can be likewise easily monitored.

7.10 Other Selected Projects

There are other projects, which may not qualify for CDM in the immediate future because of decentralized nature of accounting CO_2 reduction. The following projects have been identified for future consideration when appropriate accounting methods are made available.

(i) Solar electricity in the National Assembly building (Parliament Building), President's House, and Prime Minister's Office and Official Residence
(ii) Demonstration of efficient biomass stoves for widespread use
(iii) Demonstration of biogas plants for popularization
(iv) Demonstration of CFL and other efficient appliances for popularization
(v) Introduction of intelligent motor controllers for efficiency improvement in electrical sector
(vi) Power generation through biomass gasification

8. CONCLUSION AND RECOMMENDATIONS

8.1 Conclusion

Being situated in hot, humid and sunny region and the landmass criss-crossed by innumerable rivers and streams, Bangladesh is endowed with abundant supply of renewable sources of energy. Other RETs such as solar PV, solar water heater, solar drier, solar cooker, briquetting, etc. are being introduced by a number of government, semi-government and autonomous bodies and also some NGOs and private organizations, but the progress of implementation is very slow.

(i) Energy efficiency aspects are at a rudimentary stage. Energy Audit Cell (EAC), under GOB, carried out an energy efficiency survey of industries in 1984 with technical assistance from Arthur D. Little International Inc. and others and found that there was a potential of annual saving over 16 PJ. Another study carried out in 1993-1994 for seven factories under an ADB grant showed scopes for significant saving (21-31%). As these studies are quite old, another study is worth undertaking before embarking on implementation of energy efficiency projects in industries.

(ii) The Power Sector is running short of demand. In the year 2000-2001, the maximum supply was 3,084 MW in place of maximum demand of 3,250 MW. Out of the installed capacity of 4,005 MW, 82% was based on natural gas and the rest on hydro, diesel and furnace oil. The efficiency of oil-based power plants is very low (as low as 14%). In gas-based power plants steam turbine accounts for 63% of the total gas consumed and the more efficient combined cycle consumes only 5%. There is therefore a scope for replacement of steam turbine by combined cycle.

(iii) Demand for electricity rises sharply in the evening from sunset and continues for 4 to 5 hours every day showing the great demand for lighting during the evening hours.

(iv) According to ALGAS study, the total GHG emission of the country in 1990 was 72 million tonnes of CO_2 equivalent of which agricultural and livestock sub-sector had highest contribution i.e., 40 percent. Energy sector and forestry sector including land-use change contributed about 30 and 27 percent respectively. The remaining comes from industrial processing sub-sector.

(v) Efficient biomass stoves have a potential of saving consumption of over 312.5 PJ of energy and biogas plants show a potential of producing 3,675 x $10^6 m^3$. Solar energy has a tremendous potential in this country; but the number of installed technologies are insignificant because of high initial costs and unpredictable solar insolation especially during the rainy season. Solar PV, wind and hydro potentials are estimated at 50,436 MW, 2,000 MW and 672 MW, respectively.

(vi) In order to augment the activities related to RE and EE, National Energy Policy (1996) has been updated (now in the final draft form awaiting GOB approval) to include new policy issues to attract more investments and more activities in this field. Special incentives in respect of tax, remittances and other required facilities will be given to foreign investors.

8.2 Recommendations

(i) The objective of PREGA is to make the selected projects CDM-able. Although the projects on efficient biomass stoves, biogas plants, CFL have tremendous potential for energy savings and attendant GHG abatement, accounting of CO_2 reduction is difficult because of decentralized nature. Biomass gasification, minihydro/microhydro electricity and solar electricity in some prestigious buildings in Dhaka city needs further study because of their small sizes before inclusion as CDM-able projects.

(ii) In consideration of centralized nature, large sizes and easy accounting of CO_2 reduction, following nine projects from the list in Section 7 are recommended for pre-feasibility studies to be undertaken by the national technical experts under the PREGA Project.

(a) Waste to electrical energy project

(b) Introduction of co-generation in sugar industries
(c) Solar-wind-diesel hybrid for power generation for small towns and villages
(d) Fuel switching from oil to gas for power generation
(e) Energy efficiency studies in industries
(f) Rehabilitation of electricity distribution network
(g) Combined-cycle power plant in place of gas-steam power
(h) Conversion of gasoline cars to CNG cars
(i) Replacement of 2-stroke engine with 4-stroke engine for auto rickshaws.

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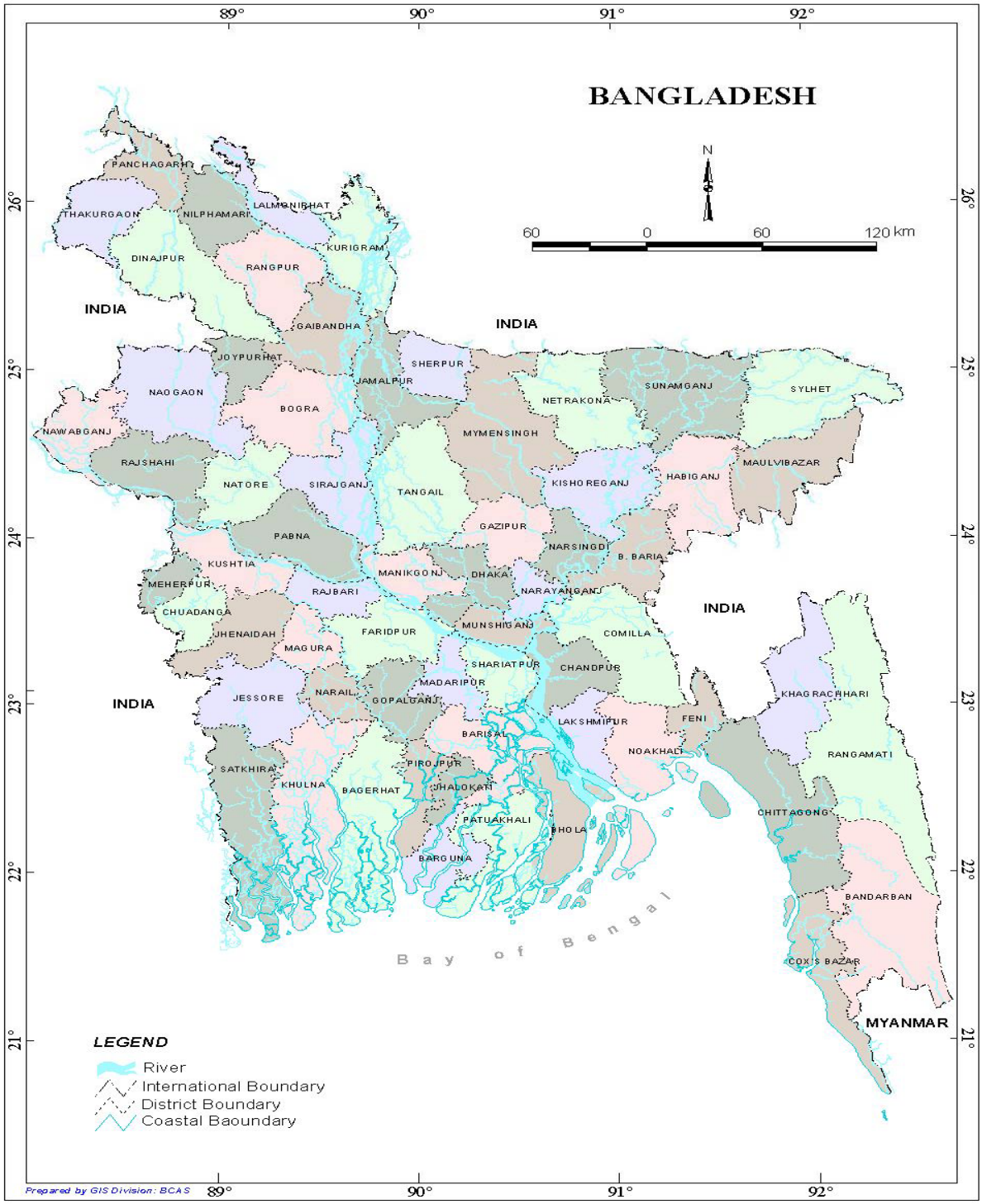
Appendix A. Map of Bangladesh



Appendix B. Price of Electricity
Dhaka Electric Supply Authority (DESA)
As of January 01, 2002

Sl. #	Classification of Client	Price/Unit (kWh)
01.	**Class - A: Residential**	
	i) 1st Step: 000 to 100 kWh	Tk. 2.15
	ii) 2nd Step: 101 to 300 kWh	Tk. 2.30
	iii) 3rd Step: 301 to 500 kWh	Tk. 3.45
	iv) 4th Step: 501 to 700	Tk. 4.50
	v) 5th Step: 700 to above	Tk. 5.70
02.	**Class - B: Agricultural Pump**	Tk. 1.75
03.	**Class - C: Cottage Industry**	
	i) Flat Rate:	Tk. 4.80
	ii) Off-Peak Hour:	Tk. 2.90
	iii) Peak Hour:	Tk. 5.10
04.	**Class - D: Nonresidential (Light & Electricity)**	Tk. 3.05
05.	**Class - E: Commercial**	
	i) Flat Rate:	Tk. 4.80
	ii) Off-Peak Hour:	Tk. 3.45
	iii) Peak Hour:	Tk. 7.45
06.	**Class - F: Medium Pressure General Use (11 KV)**	
	i) Flat Rate:	Tk. 3.45
	ii) Off-Peak Hour:	Tk. 2.85
	iii) Peak Hour:	Tk. 6.10
07.	**Class - G1: Very High Pressure DESA (132 KV)**	Tk. 2.02
08.	**Class - G2: Very High Pressure General Use (132 KV)**	
	i) Time: 23:00-06:00	Tk. 1.35
	ii) Time: 06:00-13:00	Tk. 2.25
	iii) Time: 13:00-17:00	Tk. 1.50
	iv) Time: 17:00-23:00	Tk. 5.00
	v) Flat Rate:	Tk. 2.55
09.	**Class - H: High Pressure General Use (33 KV)**	
	i) Flat Rate:	Tk. 3.25
	ii) Off-Peak Hour:	Tk. 2.75
	iii) Peak Hour:	Tk. 5.85
10.	Class - I: Rural Electrification Board (REB) [33 KV]	
	i) PDB to REB	Tk. 1.95
	ii) DESA to REB	Tk. 2.02
	Class - J: Street Lamp & Pump	Tk. 3.50

Source: www.firstbangla.com/fbe/elecprice.htm / Petrobangla

Appendix C. Price of Electricity

Rural Electrification Board (REB)
As of January 01, 2002

Sl. No.	Classification of Clients	Tk/kWh
1	Scheme-B (Domestic) 0-100 kWh 101-300 kWh 301-500 kWh Above 500 kWh	 2.41-2.75 2.45-2.76 3.70-3.95 4.75-5.62
2	Scheme-C Commercial	4.87
3	Scheme-CI CH. Inst	3.12-3.15
4	Scheme-I IRRI	2.48-2.90
5	Scheme-GP	3.12-3.85
6	Scheme-LP	3.62-3.82
7	Scheme-SL	3.57-3.60

GP = General Power, LP = Large Power, CH. Inst = Charitable Institute.
SL = Street Light

Source: REB, 2002

Appendix D. Gas Price
Bangladesh Oil, Gas & Mineral Corporation
(PETROBANGLA)
As on January 01, 2002

Sl. No.	Category of Customers	Prices per Cubic Metre (Tk)	Rates per Month (Tk)
01.	Power	2.47	
02.	Fertilizer	2.12	
03.	Industrial	4.94	
04.	Commercial	9.99	
05.	Tea Estate	4.44	
06.	Captive Power	3.53	
07.	Domestic (Residential)		
	a. Metered	4.24	
	b. Unmetered		
	i) Single Burner		325.00
	ii) Double Burner		375.00
	iii) Additional Burner (each)		98.00
	iv) Oven (each)		215.00
	v) Additional Oven (each)		108.00
	vi) Grill		215.00
	vii) Additional Grill (each)		108.00
	viii) Water Heater (up to 20 Gallons)		428.00
	ix) Water Heater (above 20 Gallons)		535.00
	x) Drier		645.00
	xi) Refrigerator		428.00
	xii) Gas Light (Outside/Garden)		98.00
	xiii) Gas Light (inside/Room)		50.00

Source: www.firstbangla.com/fbe/gasprice.htm / Petrobangla

Appendix E. Energy Balance 1990, Peta Joule (10^{15} Joule)

	Crude Oil	*Petroleum Product*	*Coal*	*Natural Gas*	*Electricity*	*Total Comm.*	*Non-Wood Biomass*	*Wood Fuel*	*Total Biomass*
I. SUPPLY							Biomass Fuels		
Indigenous Production	0.00	2.70	0.00	163.40	3.30	169.40	410.80	88.20	499.00
Import	53.40	48.00	12.30	0.00	0.00	113.70	0.00	0.00	0.00
Export	0.00	-6.30	0.00	0.00	0.00	-6.30	0.00	0.00	0.00
Stock Exchange	-5.90	-6.80	0.10	0.00	0.00	-12.60	0.00	0.00	0.00
Total Primary	**47.50**	**37.60**	**12.40**	**163.40**	**3.30**	**264.20**	**410.80**	**88.20**	**499.00**
Primary (Percent)	**6.20**	**4.90**	**1.60**	**21.40**	**0.40**	**34.50**	**53.80**	**11.60**	**65.40**
II. TRANSFORMATION									
Refinery	-47.50	44.10	0.00	-1.00	0.00	-4.40	0.00	0.00	0.00
Thermal Power	0.00	-8.80	0.00	-69.30	24.40	-53.70	0.00	0.00	0.00
Loses & Own Use	0.00	-4.00	0.00	-9.90	-8.30	-22.20	0.00	0.00	0.00
Total Final Supply	**0.00**	**68.90**	**12.40**	**83.20**	**19.40**	**183.90**	**410.80**	**88.20**	**499.00**
III. CONSUMPTION									
Domestic	0.00	23.60	0.00	9.30	4.90	37.80	337.20	67.30	404.50
Industrial	0.00	7.00	9.50	14.00	10.00	40.50	73.60	19.10	92.70
Commercial	0.00	0.00	0.40	3.10	3.60	7.10	0.00	1.80	1.80
Transport	0.00	25.00	2.50	0.00	0.00	27.50	0.00	0.00	0.00
Agricultural	0.00	11.00	0.00	0.00	0.90	11.90	0.00	0.00	0.00
Others	0.00	0.30	0.00	0.00	0.00	0.30	0.00	0.00	0.00
Non-Energy Use (Urea)	0.00	2.00	0.00	56.80	0.00	58.80	0.00	0.00	0.00
Total Final Consumption	**0.00**	**68.90**	**12.40**	**83.20**	**19.40**	**183.90**	**410.80**	**88.20**	**499.00**
Consumption Final Energy %	**0.00**	**10.10**	**1.80**	**12.20**	**2.80**	**26.90**	**60.20**	**12.90**	**73.10**

Source: National Energy Policy: January 15, 1996

Note: '-' sign before any figure indicates export (e.g. furnace oil) or transformation into other energy products (e.g. refining of crude oil).

Appendix E1. Energy Balance 2000, Peta Joule (10^{15} Joule)

	CRUDE OIL	PETRO-LEUM PRODUCT	COAL/ COKE	NATURAL GAS	ELECTRI-CITY	LPG	TOTAL COMM. ENERGY	NON-WOOD BIOMASS	WOO FUE
I. SUPPLY									
Indigenous Production	0.39	0.00	18.62	355. 98	0.00	0.00	374.99	323.12	331.
Imports	64.33	52.09	0.00	0.00	0.00	0.21	116.63	0.00	0.
Exports	0.00	-12.53	0.00	0.00	0.00	0.00	-12.53	0.00	0.
Total Primary	64.72	39.56	18.62	355.98	0.00	0.21	479.09	323.12	331.
Total Primary (Percent)	5.64	3.45	1.62	31.01	0.00	0.02	41.74	28.15	28.
II. TRANSFORMATION									
Oil Refining	-64.72	62.49	0.00	0.00	0.00	0.73	-1.51	0.00	0.
Electricity Gen.	0.00	-4.39	-0.30	-218.69	67.84	0.00	-155.54	0.00	0.
T & D Losses	0.00	-0.88	-0.15	-7.48	-18.30	-0.01	-26.82	0.00	-3.
Coke Production	0.00	0.00	-3.72	0.00	0.00	0.00	-3.72	0.00	0.
Total Final Supply	0.00	96.78	14.45	129.81	49.54	0.93	291.51	323.12	327.
III. CONSUMPTION	0.00								
Domestic	0.00	16.15	0.00	31.39	17.46	0.90	65.9	258.92	252.
Industrial	0.00	13.02	14.45	32.34	17.95	0.00	77.76	63.49	65.
Commercial	0.00	0.00	0.00	4.43	4.30	0.03	8.76	0.71	2.
Transport	0.00	50.93	0.00	0.00	0.00	0.00	50.93	0.00	0.
Agriculture	0.00	12.43	0.00	0.00	1.630	0.00	14.06	0.00	0.
Others	0.00	4.24	0.00	0.00	0.00	0.00	4.24	0.00	7.
Urea (Non-Energy)	0.00	0.00	0.00	61.65	8.19	0.00	69.84	0.00	0.
Total Final Consumption	0.00	96.77	14.45	129.81	49.53	0.93	291.49	323.12	327.
Final Consumption (Percent)	0.00	10.11	1.51	13.56	5.18	0.10	30.46	33.71	34.

Source: Pl. Comm. (2002), adapted.

Note: '-' sign before any figure indicates export (e.g. furnace oil) or transformation into other energy products (e.g. refining of crude oil).