ASIA LEAST-COST GREENHOUSE GAS ABATEMENT STRATEGY (ALGAS)

Bankable Least-Cost GHG Abatement Initiatives

Task - C.6

Prepared by

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DISSEMINATION OF IMPROVED COOKING STOVES IN RURAL AREAS OF BANGLADESH

1. COUNTRY BACKGROUND

The People's Republic of Bangladesh lies between $20^0 34'$ and $26^0 38'$ north latitude and between $88^0 01'$ and $92^0 41'$ east longitude. The country is bounded by India on the North and on the West, by the Bay of Bengal on the South, and by India and Burma on the East. The area of the country is 148,393 square kilometres. It is mostly a low and flat deltaic land with the exception of some hilly areas in the north-east and south-east and some high lands in the north and north-east. The country is also one of the most natural hazard prone countries of the world and is visited regularly by floods and cyclones, and occasionally by droughts.

In 1991 the population of the country was 111.4 million. The percentage of urban population was 20.1, the rest being rural. The density of population was estimated to be 755 per sq. km. The inter-censal growth rate of population estimated by using adjusted population of 1991 census was 2.1 percent per annum. Under certain plausible assumptions, the population of the country is expected to reach 129.6 million by 2000 A.D.

Bangladesh has a few proven mineral resources viz. natural gas, coal, peat, limestone, hardrock, lignite, silica sand, white clay etc. The country has enormous deposit of natural gas. So far, 17 gas fields have been discovered from which natural gas is available for power generation, industrial and other uses.

In 1995-96 the estimated per capita GDP in the country was Tk. 5051 (at constant market price of 1984-85) or US$ 125 approximately. The per capita GDP at current market price is nearly double of this amount.

With a per capita national income of around US$ 250 Bangladesh is one of the poorest countries of the world. Agriculture is the single most important economic sector contributing nearly 35 per cent to GDP. Industries account for only 10-12 per cent of GDP, while the rest is contributed by services.

2. SECTOR BACKGROUND

In 1990, out of a total consumption of 683.0 PJ, 411.97 PJ energy was consumed for cooking purposes only. Bio-mass is the major source of energy for cooking, accounting for about 95.6% of share; of which agri-residues supply about 56.9% of total energy used for cooking (Task Force, 1991). This clearly demonstrates that the overall domestic energy consumption for cooking is highly dependent on bio-mass and more specifically on agri-residues. The traditional cooking device has an efficiency of about 7~8%.

With its population, economic growth and development potential, the country's demand for energy will increase in future. It may be envisaged that supply of commercial energy will increase and those will be utilized for cooking purposes, but the rate of increase in demand may not be completely satisfied with increasing supply of commercial energies, e.g., gas, kerosene etc. Under such a situation the people will face acute energy shortage for cooking purposes.

Statistics show that horizontal expansion of agriculture will not be possible, rather the existing arable land will decrease with expansion of settlement and urban areas. This trend will lead to a possible decline in availability of agri-residues in near future. This will, eventually, put further constraints on availability of fuel for cooking purposes.

Presently Bangladesh is facing a severe shortage in electricity which, among other things, restricts further development of industry sector. Possibility for providing electric power for urban domestic cooking will also be restricted in near future unless dramatic improvement takes place in power sector development. Present supply of kerosene and liquefied petroleum gas (LPG), both imported from abroad in exchange of foreign currency, is limited. Although many urban households are using kerosene as cooking fuel, with a recent hike in price for petroleum products, kerosene will no longer remain popular.

In Bangladesh virtually there is no land for grazing and livestock sector is facing a severe shortage in animal feed. Most of the fodder are being used for cooking purposes. Moreover, draft-animals are replaced by tiller machines, the latter being more cost-effective in terms of maintenance. This has caused a decline in bovine population throughout the country and as a result, total production of dung is declining. This forces the rural households to depend more and more on agri-residues and homestead forests as sources of energy.

With such a backdrop, it is imperative to look for either an alternative and cheap source of energy for cooking, or to check whether the energy efficiency for domestic cooking, especially with agri-residues and tree residues, could be increased. Present level of understanding support the latter idea and force us to ponder about replacement of the existing traditional cooking stoves (TCS) with about 40% more efficient improved cooking stoves (ICS).

3. PROJECT GOAL

To improve the living condition of the rural population by introducing efficient cooking devices.

4. PROJECT OBJECTIVES

The project has several objectives, present below:
To increase energy efficiency and save bio-mass fuel
To help rural poor people to increase savings by saving fuel costs
To improve health situation of the rural women working in kitchens
To replace about one million traditional cooking stoves (TCSs) by improved cooking stoves (ICSs).

5. OUTPUTS

5.1 The output of the proposed project will be:

a) Replacement of about 200,000 TCSs per year with ICSs; a total of one million stoves will be replaced

b) Saving about one million tons of fuel-wood and about one million tons of agri-residues per year after completion of the project

c) Saving about 3.55 Tg carbon-di-oxide equivalent per year after the completion of the project

d) Develop a people oriented mechanism to popularize ICS in rural areas

e) Strengthening local potters as support centers by providing credit and developing human resources through training.

6. STATE OF PREPARATION

6.1 Replacement of TCSs with ICSs is a demand side management measure which will save scanty bio-mass resources through improvement of efficiency of the device. If the fuel is saved, it will also allow the users to go for alternative environment-friendly uses of the saved bio-mass. Moreover, it will perhaps save the remaining forests from being denuded and at the same time, improve the air quality inside the kitchens. All these potentials should therefore be exploited, even if the government has to provide subsidies at the initial stages of the project.

6.2 It may therefore be envisaged that ICSs, through an incentive based scheme, may be disseminated in rural households starting from 1999. The objective may be set that by the year 2004 about one million households would use ICSs instead of TCSs.

6.3 ***Executing Agency/Agencies***

The ICS dissemination programme may necessitate an effective collaboration between the following agencies:

i) Ministry of Local Government
ii) Local Government Engineering Department (LGED)
iii) Bangladesh Council for Scientific and Industrial Research (BCSIR)
iv) Non-government Voluntary Development Organizations (BRAC, Proshika-MUK, ASA, Shawnirvor Bangladesh, RDRS, Nigera Kori, ADAB, CEN etc.)
v) Grameen Bank Limited, Grameen Trust
vi) Ministry of Information
vii) Bangladesh Betar
viii) Bangladesh Television

7. BARRIERS TO THE REPLACEMENT OF TCSs WITH ICSs

The following are considered as barriers in disseminating ICSs in Bangladesh

The grates (sieves) used inside each ICS unit is fragile and may need frequent replacement

The exhaust pipe needs frequent cleaning, soot often clog the pipe and smoke may be pushed back inside the kitchen resulting into an unhealthy atmosphere and annoyance

The exhaust pipe may require occasional replacement. People may find it difficult to carry a considerably long earthen fragile pipe from local market to his/her home

Very low income households may find it costly (!) to replace

Replaceable spares (e.g., grate, pipe etc.) may not be easily available

Technical knowledge (practical) for replacement of such spare parts may not appear adequate for a common person.

8. THE WAY TO OVERCOME THE BARRIERS

The project is expected to overcome the above mentioned barriers by adapting to the following measures:

a) The local artisans (potters) to be provided with adequate training to make the ICS unit, each of its spare parts etc. They will also be provided with a small "seed money" as credit to make the first lot and start a business out of it. They will then continue to make spare parts and sell those in local markets at reasonable price.

b) A media campaign to be launched to educate the rural people about the advantages of using ICSs instead of TCSs. A documentary film may be prepared in this connection which will highlight different aspects of it. The film may then be broadcast in television and cinema-halls for wider dissemination of information and awareness raising.

c) Ministry of Information should be involved and given leadership to run the campaign. Television and radio would broadcast programmes free of cost on behalf of the government.

d) The dissemination programme should be led by LGED in collaboration with the NGOs/PVDOs, The branches of those NGOs and Grameen Bank are spread all over the country and they work with local communities. This may be utilized advantageously for disseminating ICSs.

If necessary the NGOs may consider dissemination activity as a part of their income generating credit programme.

9. IMPLEMENTATION PROGRAMME

The dissemination aspect of the project appears to be more complex and diffused when compared to issues such as media campaign and training. If the government and NGOs take a concerted effort then it is envisaged that 200,000 ICS units will be disseminated annually for initial five years, starting from

January 1999. For wider acceptance the first million of ICS units will be disseminated free of cost. It is expected that by the completion of the dissemination programme ICS will gain enough credibility and popularity so that no further subsidy would be necessary in future.

While the LGED and NGOs would be disseminating the units, LGED would organize training for the local potters in each target community. Training will be scheduled in such a way that all the target communities will be covered by the end of 1999 (first year of the project).

The Ministry of Information (MOI), with its sister agencies (BTV, Bangladesh Betar), will design and launch a media campaign which will continue during the first two tears of the project. It is hoped that by the year 2001 people will become aware of the ICS and accept it into their kitchen.

10. **BUDGET FOR THE PROJECT**

The total costs of the project over its life is estimated to be Tk. 22793 million or US$ 530 million. The budget is detailed out in Table-1 below.

Table-1: The proposed budget for the project

(in million Taka)

Cost category	**Year-1**	**Year-2**	**Year-3**	**Year-4**	**Year-5**	**Total in 5 yrs**
Capital	30.00	30.00	30.00	30.00	30.00	**150.00**
Labour	92.00	184.00	276.00	368.00	460.00	**1380.00**
Spare parts	16.00	32.00	48.00	64.00	80.00	**240.00**
Fuel	139.60	2789.20	4183.80	5578.40	6973.00	**20919.00**
Training	2.88	0.00	0.00	0.00	0.00	**2.88**
Credit	1.15	0.00	0.00	0.00	0.00	**1.15**
Campaign	50.00	30.00	20.00	0.00	0.00	**100.00**
Total costs	1586.63	3065.20	4557.80	6040.40	7543.00	**22793.00**

11. **PROJECT FINANCING**

The project is proposed to be financed from the GEF fund, the multilateral Banks credit and the GOB's revenue budget. GEF may provide a total of Tk. 150 million or US$ 3.5 million, i.e., only the capital cost for making the first million ICSs. It is envisaged that the users will bear for fuel, labour and costs for spare parts, while the government will bear training and campaign costs and arrange credit from sources as may be decided upon by the government.

12. **INCREMENTAL COST**

The project is an example of win-win situation, but the poor people in Bangladesh may not understand it unless it is well understood and practiced. Since the poor rural families do not spend any money for TCSs, they would not accept alternative devices, even if it cost only Taka 150.00 (US$3.50). The only way to popularize the ICS units is to give them free of cost until its advantages are being understood by everyone in the community. Therefore it is considered that the capital cost of making one million stoves would be termed as incremental cost of the project, the total amount to be sought from either the GEF or the multilateral Banks as credit. Other costs may be provided by the government from its revenue budget.

13. **SOCIO-ECONOMIC IMPACTS**

The poor families would love to have some device which would tend to curtail some fuel-cost. The time which could be saved could be used for other purposes, most importantly the housewife could spend more time with her children. Since smoke would be guided towards outside of the kitchen through the exhaust pipe, the health situation of the housewives would be improved without spending any additional amount of money.

Fuel savings would not only mean saving money, but it may lead to save some fuel material as well. If some dung is saved it could be used as fertilizers in crop fields or in homestead gardens. That is how the quality of a degraded land could be improved, once again, without involving any additional cost. Similarly, if some fuel-wood is saved that would mean that some wood lots would not be destroyed. That would in turn grow as an asset for the owner. All these have positive impacts on socio-economic aspects of rural households.

The NPV (Annex-I) and the benefit-cost ratio indicate that the project is economically and financially viable. Further, the extent of GHG emission abatement due to the project also strengthens the acceptability and the viability of the project.

14. SUSTAINABILITY

It has been demonstrated by some small NGO that people in rural areas accepted such ICS units and adapted to the new technology very well. Those who have accepted ICS units learnt themselves how to solve silly troubles. By practice they came to know that ICS saves fuel, money, time and also it does not pollute the kitchen. The pilot dissemination programme demonstrated that people are satisfied with the ICS units.

From that experience one may infer that the ICS will be popular in other areas of the country. The advantages of using such units will guarantee sustainability of the project if adequate measures for removing the barriers (i.e., awareness raising and training) are taken.

15. RATIONALE FOR GEF SUPPORT

Since the capital cost for making one million ICSs would be needed just to popularize the device, the amount should be considered as incremental cost. Replacing traditional stoves by improved stoves in about 22 million homes may require longer time compared to the proposed project life and the associated costs may be borne by the users and the government.

As presented in Table-1 the incremental cost therefore amounts to Tk. 150 million (i.e., US$ 3.50 million) which would allow to abate annually a total of 3.55 million tons of carbon-dioxide equivalent after the completion of the project. Thus with a GEF grant of Tk. 150.0 million (incremental costs) the GHG abatement cost will come to Tk. 42 or US$ 1.00 (approximately) per tons of CO_2.

The cost for making the first million ICS units is sought from GEF, not the costs for entire 22 million units, one each for every household. It is necessary to recognize the fact that ignorance regarding such technologies among the poor people is the first barrier to remove and GEF has mandate to remove such barriers. The proposed project seeks only the initial money to take first step in removing the barrier, which is fully justified.

The dissemination of improved cooking stoves is therefore consistent with the *Long Term Measures* component for removing implementation barriers for technologies as defined in the GEF Operation Strategy. The programme is cost effective. The unit cost of saving CO_2 emission is only a fraction of the lower range described in the GEF Operation Strategy between US$ 5.30 and 10 per tons of carbon abated.

Annex-I:

Costs (annual)	**year-1**	**2**	**3**	**4**	**Year-5**	**total costs**
Capital costs	30.00	30.00	30.00	30.00	30.00	150.00
Labour	92.00	184.00	278.00	368.00	460.00	1380.00
Spare parts	16.00	32.00	48.00	64.00	80.00	240.00
Training	2.88	0.00	0.00	0.00	0.00	2.88
Credit	1.15	0.00	0.00	0.00	0.00	1.15
Campaign costs	50.00	30.00	20.00	0.00	0.00	100.00
Total costs	192.03	276.00	376.00	462.00	570.00	1874.03
Saved Costs (benefits)						
Fuel	497.80	995.60	1493.40	1991.20	2489.00	7467.00
Net benefit	305.77	719.60	1117.40	1529.20	1919.00	5592.97
	million Tk.	million US$				
NPV cost =	25.34	0.59				
NPV benefit =	44.66	1.04				

Notes:

1. NPV is estimated at 8% discount rate.
2. Net benefit is estimated as the difference between the fuel costs required under the traditional & improved cooking stoves.
3. Firewood requirement per stove per annum:
   (a) traditional stoves - 3498Kg
   (b) improved stoves - 2531Kg
4. Price of firewood (as of 1997) Tk 2.7 per Kg.

PROJECT TITLE	:	BANGLADESH : Replacement of Incandescent Bulbs with Compact Fluorescent Lamps (CFL)
GEF FOCAL AREA	:	Global Warming Mitigation
TOTAL PROJECT COSTS	:	
GOVERNMENT COUNTERPART	:	
FINANCING : Local	:	
Foreign	:	
GEF FINANCING	:	
CO-FINANCING	:	
GEF IMPLEMENTING AGENCY	:	WORLD BANK / UNDP
EXECUTING AGENCY	:	Bangladesh Electricities Supply Cons., Govt. of Bangladesh
ESTIMATED STARTING DATE	:	1999
PROJECT DURATION	:	20 Years
GEF OPERATIONAL FOCAL POINT	:	Ministry of Energy and Mineral Resources Govt. of Bangladesh

REPLACEMENT OF INCANDESCENT BULBS WITH COMPACT FLUORESCENT LAMPS (CFL)

BACKGROUD

1. COUNTRY BACKGROUND

1.1 The People's Republic of Bangladesh lies between $20^0 34^/$ and $26^0 38^/$ north latitude and between $88^0 01^/$ and $92^0 41^/$ east longitude. The country is bounded by India on the North and on the West, by the Bay of Bengal on the South, and by India and Burma on the East. The area of the country is 148,393 square kilometers . It is mostly a low and flat deltaic land with the exception of some hilly areas in the north-east and south-east and some high lands in the north and north-east. The country is also one of the most natural hazard prone countries of the world and is visited regularly by floods and cyclones, and occasionally by droughts.

1.2 In 1991 the population of the country was 111.4 million. The percentage of urban population was 20.1, the rest being rural. The density of population was estimated to be 755 per sq. km. The inter-census growth rate of population estimated by using adjusted population of 1991 census was 2.1 percent per annum. Under certain plausible assumptions, the population of the country is expected to reach 129.6 million by 2000 A. D.

1.3 Bangladesh has a few proven mineral resources viz. natural gas, coal, peat, limestone, hard rock, lignite, silica sand, white clay etc. The country has enormous deposit of natural gas. So far, 17 gas fields have been discovered from which natural gas is available for power generation, industrial and other uses.

1.4 In 1995-96 the estimated per capita GDP in the country was Tk. 5051 (at constant market price of 1984-85) or US$ 125 approximately. The per capita GDP at current market price is nearly double of this amount.

1.5 With a per capita national income of around US$ 250 Bangladesh is one of the poorest countries of the world. Agriculture is the single most important economic sector contributing nearly 35 per cent to GDP. Industries account for only 10-12 per cent of GDP, while the rest is contributed by services.

2. *SECTOR BACKGROUND*

2.1 In 1990, Bangladesh used 683.0 Pj of energy, if which only 27% was from commercial energy sources. About 5390 GWh electrical energy was consumed in 1990 (Task Force, 1991). The current demand for electricity is about 2000 MW, while The current supply is about 1800 MW. Of this domestic use account for 37.7% (PSMP). In 1994 a total of GWh of electricity energy was consumed, of which the urban domestic , the rural domestic, the industrial and the commercial sectors consumed about 1096 GWh, 566 GWh, 422 GWh and 470GWh, respectively (PSMP Vol. 3, pp. BP4-18).

2.2 With the economic growth and development the demand for energy in Bangladesh will grow further presumably, at an increasing rate. However, on a very conservative estimate depending on

historical data for electricity consumption growth rate in different sectors and making adjustment for changing future economic conditions, one may forecast the demand for electricity in the country for a future date . Thus calculating only a 6% annual growth rate for electricity demand in urban domestic sector (see Table-4 in BPDB/ADB, Power System Master Plan, Bangladesh, Vol. 2), the respective sectoral demand will come to approximately 745 GWh, 2191 GWh, 19824 GWh and 3750 GWh in the year 2020, the base year being 1994. At the present rate of consumption for lighting the lighting demand then will amount to 4470 GWh, 1972 GWh, 2974 GWh and 2625 GWh in the urban domestic rural domestic, industrial and commercial sectors respectively .

Table-1 : Electricity Use For Lighting By Types Of Lamps

Sector	Total Electricity energy use GWh	% for lighting	Devices* %	
			Incandescet	Fluorescent
Rural household	629	90	100	--
Commercial sector	671	70	40	40
Urban household	1686	65	75	25
Industry	2813	15	60	40
Agriculture	332			
Municipal street light	17			
All Sectors	6148			

- Estimate by the ALGAS Team. All the other data were taken from PSMP, Vol. 3, 1995.

2.3 Bangladesh is now facing severe electricity shortage particularly, during peak hours, and a substantial portion of the peak demand is residential and commercial lighting. It is frequently necessary for the Bangladesh power system to resort to load shedding as a demand management tool. In the calendar year 1994, for example, load was recorded as having been shed on a total of 270 days in amounts ranging from 20 to several hundred megawatts over the evening peak period. The situation is sure to deteriorate further unless appropriate measures are taken either for electricity conservation or for further generation of electricity or for both. The paradigm “it is better to save one KW-h than to generate one KW-h” is probably the most appropriate policy measure for Bangladesh at the moment, nay, even at medium term, because investments in new generating capacity has become very difficult to come by. The electricity generation in Bangladesh is mainly dependent on natural gas for fuel, but the system is constrained within the next 8 to 10 years, unless there is additional investment in gas drilling, exploration and transmission is made. Alternatively, the country will have to choose the option of imported fuel oil based power generation, which is a very costly option. Under the circumstances one has to look for a third option which would be effective, efficient and demand satisfying at least in the short-run.

2.4 One way to face the shortage of electricity supply in Bangladesh is to save it without affecting its usage functions. The most effective mechanism to do so is to replace the existing large-scale use of incandescent light bulbs with smaller wattage bulbs, viz. compact fluorescent lamps (CFL),

which consume only one-fifth of power that an incandescent bulb consumes. In addition, CFL has a life ten times more than that of the incandescent bulb.

2.5 In Bangladesh, it can safely be assumed that virtually 100% of all rural domestic electric lighting is provided by the incandescent light bulbs which in urban household, commercial and industrial sector the corresponding percentage is always were than 60 (Table-1). The reason for this is related directly to the higher capital cost of fluorescent tubes and fixtures. It is estimated that an incandescent bulb and holder costs only about 10% of what a fluorescent tube and holder would cost. Nevertheless, over a short to medium term, a shift to high-efficiency fluorescent tubes with electronic ballast's could result in at least, a 50% decrease in lighting energy requirements.

3. PROJECT GOAL

The goal of the project is to lower GHG emission by using efficient appliance/ devices of lighting.

4. PROJECT OBJECTIVES

- To replace at least 50% of all incandescent bulbs with CFLs by the year 2020.
- To save consumption of electricity for lighting ;
- To increase energy efficiency ;
- To limit use of gas and other feedstocks in power generation particularly, for lighting ;
- To face the present shortage of electricity supply in Bangladesh without affecting its usage functions ;

5. OUTPUT

The output of the replacement of an incandescent bulb with a CFL will be : (1) savings of electricity for lighting. If a 60W incandescent bulb is replaced by an incandescent equivalent CFL one saves 45W per hour which becomes 450 KWh over the life of a CFL; (2) in money terms one saves at least a net amount of Tk. 100 per CFL over its life even at the present rate of taxes (60%); (3) thus, the total energy saved for each 100,000 CFLs is 45 GWh and the savings in terms of money at 1997 constant price is approximately Tk. 11 million (see Table-2) ; and (4) over the life of the project (1999-2020) CO_2 emission will be saved to the tune of 2.64 million tonnes (see Table-5).

Table- 2 : Comparison Of CFL And Incremental Lamps

(Savings From CFL Use)

	CFL	Incandescent
1. Characteristics		
i)Power consumption (for 60 W incandescent equivalent)	15 W	60 W
ii) Useful life	10,000 hrs.	1,000 hrs
iii) Investment cost per lamp	Tk. 900	Tk. 20
iv) Operating cost	0	0
v) Electricity rate	Tk. 1.80/kwh	Tk. 1.80/kwh

2. Life cycle energy savings = (60w - 15w) X 10,000 hrs = 450 kwh

3. Life cycle costs : CFL = Tk.900
Incandescent = 20 X 10= Tk. 200

Net Incremental Cost For Cfl =(Tk.900 - Tk.200) =Tk. 700

4. For each 100,000 CFL disseminated, energy saved over life cycle
= 450kwh.X100,000 = 45 Gwh
5. Value of energy saved per 100.000 CFL
= 450kwh. X 100,000 X Tk. 1.80 = Tk. 81 mn.
6. Net incremental cost per 100,000 CFL
=Tk.700 X100,000 =Tk.70 mn.
7. Net savings per 100,000 CFL
= (81 mn. - 70 mn.) =Tk. 11 mn.

6. STATE OF PREPARATION

6.1 Replacement of incandescent light bulbs with CFLs is a demand side management measure which will save electricity through substantial reductions in peak period electricity demand for lighting. The project bears significant importance in the present day economic and environmental perspectives of the country. Given the socio-economic condition of the country as of today it is difficult for the Government to invest in new generating capacities nor is it advisable to do so particularly for meeting the electricity demand for lighting since a very good technology exists to reduce energy consumption in this sector. The saving potential of the technology should therefore be exploited even if it requires the Government to subsidies the technology at its initiation.

It may therefore be envisaged that through an incentive based scheme CFLs may be disseminated starting in 1999. The objective may be set that by the year 2020 at least 50% of all incandescent bulbs will be replaced by CFLs.

6.2 Executive agency/ agencies

The CFLs dissemination program may have one or all of the following partners :

1. Utility company or any private company set up for the purpose ;

2. A CFL manufacturing or supplying company

3. Power Development Board or relevant department of the Ministry of Energy and Mineral Resources.

7. BARRIERS TO THE REPLACEMENT OF THE INCANDESCENT BULBS

WITH CFL :

The following are the major barriers to the dissemination of CFLs in Bangladesh.

(i) (i)The CFL tubes and fixtures are very costly. The Government of Bangladesh has levied a 60% tax on CFL. When all costs are added to its import price, the final retail price per CFL comes to around Tk. 900.00 (US$ 21), a price which is beyond the capacity to pay for almost all the consumers excluding only a few affluent users ;

(ii) The manufacturing technology of these lamps do not exist in Bangladesh and it may be quite some time before it can be acquired ;

(iii) With the introduction and large-scale dissemination of CFL the existing incandescent bulbs manufacturing industry will suffer and as a consequence there will be loss of employment ;

(iv) The retailers and shop-keepers of incandescent bulbs will also suffer at least, an initial shock and employment losses ; and

(v) The country will suffer considerable foreign exchange loss for importing these lamps.

8. THE WAY TO OVERCOME THE BARRIERS

The project is expected to overcome the barriers through the adoption of the following measures :

1. First the GOB will withdraw all taxes including VAT, or subsidies the program ;

2. The CFL company or importing agency will supply CFLs at the minimum possible price on credit to the utility or private disseminating company ;

3. Utility will employ several different schemes to disseminate CFLs depending upon customers. Such schemes may include outright sales and/ or sale on installment basis etc. ;

4. The CFL dissemination program will offset many of the lost jobs in the incandescent bulb industry ;

5. Once the CFLs are accepted in a wide range market will expand and local producers may start producing it. This will create new employment opportu- nities on the one hand, and lower cost of the technology on the other ;

6. The dissemination program through proper propaganda in the media may promote its acceptance among the consumers particularly, at the household levels and demonstrate it as a viable measure that saves energy, lowers electricity bills and reduces air pollution. This will strengthen social acceptance of the technology even at a comparatively high initial cost, and will create essential incentives for private investments in the technology within the country. This will save foreign exchange expenditure for importation of the CFLs. This however, will take some time.

9. IMPLEMENTATION SCHEDULE

9.1. Given the socio-economic situation of the country as of now it is not possible nor recommendable to replace all the incandescent bulbs with CFL at a time. The project will also involve huge amount of foreign exchange which is otherwise required for investment in more urgent development projects. So, this replacement program may be initiated phase by phase as is shown in Table-3 below.

Table-3 : Phase-wise dissemination of CFL

Year	No. of CFLs Disseminated	Total (cumulative to the end year)
1999	100,000	100,000
2000	100,000	200,000
2001-2005	110,000- 150,000	850,000
2006-2010	170,000- 250,000	1890,000
2011-2015	275,000- 375,000	3515,000
2016-2020	400,000- 500,000	5765,000

9.2. Since the price of a CFL is comparatively high and in most cases beyond the purchasing capacity of an ordinary consumer it will be difficult to persuade him to buy it whatever be the long-run benefit, nominal or real, of its usage. Cash is very dear to people and under normal circumstances they do not want to part with it unless they are very sure about its returns. In the circumstances, the authorities may make the following implementation scheme and reach the lowest ebb of the consumers ultimately.

The First Phase : In the first phase the following may be targeted :

1. Government offices, Autonomous institutions/ offices, Hospitals, Schools etc.
2. Large offices (private, NGOs etc.)
3. Large industries (private, public).

The Second Phase : In this phase the following may be added to the left-outs in the first phase :

1. Large Commercial Establishments
2. Affluent Urban Households
3. Medium to small size industries

The Third Phase : The third phase will include among others the following :

1. Urban Households
2. All Urban Commercial Establishments etc., and
3. Rural affluent households.

And so on, till the replacement of all the incandescent bulbs and creation of a demand-driven CFL market come by.

10. BUDGET FOR THE PROJECT

The total cost for the CFLs over the life of the project (1999 - 2020) at 1997 market price comes to Tk. 5192 million (US$ 121 Mn). The cost will become almost double if an annual inflation rate, even at 4% is considered over the life of the project.

The incremental cost for replacement of incandescent bulbs by CFL inclusive of a 25% dissemination cost but excluding incandescent bulb prices (10 Incandescent = 1 CFL) over the life of the project comes to Tk. 5340 million (US$ 124.19 mn.) only (Table-4).

11. PROJECT FINANCING

The project will be financed by the GOB and the GEF's relevant fund in phases. The budget as placed above may be reviewed and revised from time to time depending on the changes in the price levels of the lamps and energy.

12. INCREMENTAL COSTS

The incremental costs of introducing and disseminating CFL in Bangladesh may be conceived in the following ways :

Alternative 1 : Consider only the financial costs of the replacement of incandescent bulbs with the CFL together with its dissemination costs. In these case the total incremental cost over the life of the project will be the difference between the costs of CFL and that of the incandescent plus the dissemination costs which amounts to Tk. 5340 million (US$ 124 million), at 1997 constant prices of the lamps (Table-4).

Alternative 2 : Consider that the government removes all taxes from CFL (60%) for achieving a greater real benefit in terms of saving electricity and saving CO_2 emission. If this is done so, the incremental cost for CFL introduction and dissemination will be the differences between the financial incremental costs (alternative 1) and the tax amount on CFL. Thus estimated the incremental costs will come to (Tk. 5340 - 1947) or Tk. 3393 million (US$ 79 mn.)

Alternative 3 ; Consider that the value of electricity saved at consumers' level (for lighting) due to the introduction of the CFL, is deducted from the costs of CLF, at the present rate of Tk. 2 per KW. Under the consideration the incremental costs and the price of saved electricity i.e.,. (Tk. 5340 million - 5190 million) Tk. 150 million, (US$ 3.5 million).

13. SOCIO-ECONOMIC IMPACTS

Widespread adoption of CFL will result in laudable medium-to-long-run positive impacts though some short-run negative impacts seems unavoidable. On a balance the benefits will definitely outweigh the short-run temporary disbenefits.

In the first phase, with a large-scale introduction of the CFL the existing incandescent bulb manufacturing industry will suffer and as a consequence there will be a loss of employment. Some employment at the retail level will also be lost at least initially.

Secondly, since the CFL manufacturing technology does not exist in Bangladesh, these lamps will have to be imported and in doing so the country will lose a substantial amount of the hard earned foreign exchange.

But these shortfalls will be minimal compared to the advantages. The large CFL dissemination program will offset many of the lost jobs in the incandescent bulb industry. The savings accrued to the government in the form of less generation capacity and transmission and distribution infrastructure will mean that the government can channel this fund into more productive sectors and in that way generate employment and wealth. In addition to these rather indirect benefits the project will accrue commendable direct benefits.

Firstly, the program, if implemented, will save electricity generation to the tune of about 44.90 Pj over its life cycle (see Table-4). This means the energy savings per CFL (against a 60w

incandescent bulb) over its life is 450 kwh. This can be translated into a net saving of Tk. 11 million (about US$ 0.25 million) per 100,000 CFL (see Table-1).

Secondly, savings in electricity generation at power plants will save GHG emission over the life of the project which stands at around 2.64 million tonnes (see Table-4). The implementation of the program thus decreases air pollution.

In the third place, the peak period demand for electricity can be met without resorting to the present practice of load shedding. This will have tremendous positive socio-political impacts.

Last but not the least, the project will envisage no known negative socio-cultural impacts.

Table- 4 : The Budget : Costs of CFL Dissemination

Year (1)	No. of new CFL replacing incandescent lamps (2)	Total CFL Price (million Tk.) (3)	Total price of Incandescent (million Tk.) (4)	Dissemination cost of CFL 25% of col. 3 (million Tk.) (5)	Incremental finance requirement (col. 3-4-5+6) (million Tk.) (6)
1999	100000	90	20	23	93
2000	100000	90	20	23	93
2001	110000	99	22	25	102
2002	120000	108	24	27	111
2003	130000	117	26	29	120
2004	140000	126	28	32	130
2005	150000	135	30	34	139
2006	170000	153	34	38	157
2007	185000	167	37	42	172
2008	205000	185	41	46	190
2009	230000	207	46	52	213
2010	250000	225	50	56	231
2011	275000	248	55	62	255
2012	300000	270	60	68	278
2013	325000	293	65	73	301
2014	350000	315	70	79	324
2015	375000	338	75	85	348
2016	400000	360	80	90	370
2017	425000	383	85	96	394
2018	450000	405	90	101	416
2019	475000	428	95	107	440
2020	500000	450	100	113	463
Total	5765000	5192	1153	1301	5340

Notes :

1. Estimates are made at 1997 constant market price. Figures are round up.
2. GOB has levied a 60% tax on CFL import price and a 40% on incandescent bulb price.
3. The retail price of a 60w incandescent bulb at present is Tk. 20 and that of a CFL is Tk. 900 (inclusive of VAT and sales tax in both the cases).
4. 10 Incandescent bulbs are considered for replacement of 1 CFL.
5. Dissemination cost includes establishment costs, labour costs, advertisement costs etc.

Table-5 : Energy And Co_2 Emission Savings Over The Life Of The Project

1. Electricity Savings :
   a) Total Lamps to be disseminated during 1999-2020 (nos.) : 5765,000
   b) Energy saved per 100,000 CFLs : 45 GWh
   c) Energy saved over the project's life (45 GWh X 57.65) = 2594.25 GWh
   d) Saved 20% "Technical System Loss" at Electricity Generation (2594.25/1-0.2-259425) =648.56 GWh
   e) Total Energy Saved (c+d) : 3242.81 GWh

2. Petajoules of Energy Saved at Generation :
   a) Total Peta joules : GWh X 3.60 X 10^{-3} / 0.26 (eff. rate) = 44.90 pj
   b) Generation by Gas (74%) Pj X 0.74) = 33.23 Pj
   c) Generation by Diesel (26%) Pj X 0.26) = 11.67 Pj

3. CO_2 Emission Saved

By Gas Turbines = 1780 Gg
By Diesel Generations = 856 Gg
Total : (1780+856) = 2636 Gg or 2.64 million tonnes

Notes : Carbon Emission Factor :
Natural Gas : 15300 tC/ Pj
Diesel : 20200 tC/ Pj
Fraction of Carbon oxidized :
Gas : 0.955
Diesel : 0.990

14. SUSTAINABILITY

The saving of energy without affecting its usage value is definitely a superior strategy to investment in new generating capacities. CFL is an efficient technology that saves 80% electricity consumption for lighting compared to incandescent technology without affecting lumen in anyway. Thus the technology should normally be easily sustainable. The preliminary economic analysis indicates that over the life of a CFL the user saves more than Tk. 100 (Table-2) although the initial cost of installing a CFL is several times higher than an incandescent bulb. At 8% discount rate the incremental cost over the life of 1 CFL at present is only Tk. 67 or US$ 1.55 (annex. 1) which is one tenth of the value of energy saved per CFL. These facts, strengthen the financial as well as the economic sustainability of the project.

Further, the project will not entail any operating cost given the present structure of electricity distribution, transmission and distribution infrastructure, availability of installed fixtures etc. at the consumption points. All these further strengthen the sustainability of the project.

If the project is implemented the consumers will hopefully be relieved from the inconvenience of load shedding. An assurance of continuous and uninterrupted electricity supply is definitely a welcome approach and socially acceptable even at an initial higher cost.

The sustainability of the project is further enhanced by the fact that it reduces GHG emission and to the extent improves people's quality of life.

15 RATIONALE FOR GEF SUPPORT

15.1. Of the total electricity generated in Bangladesh about 74% is generated by gas turbines and the rest basically by diesel generators which are associated with emission of carbon dioxide (CO_2) and other particulate. CO_2 is a greenhouse gas (GHG) and limiting its high level of emission is a major issue in global warming and climate change debates.

15.2. In Bangladesh emission data of power plants do not exist and therefore standard data similar of power plants can be used. The replacement of incandescent bulbs with CFL , as proposed, saves electricity to the tune of 2594.25 GWh (see Table-5) over the project's life. Added to this a "technical system loss" at 20%, the total savings amounts to 3243 GWh which at the present efficiency rate comes to 44.90 Pj (Table-5). Using standard data of CO_2 emission from primary energy sources, this savings in electricity generation can be translated into savings of CO_2 emission at about 2.64 million tonnes (see Table-5).

15.3. The main barrier to the dissemination of CFL in Bangladesh is its high initial price. Whatever be the real benefit of its usage people in general will not be ready to pay a price about 45 times higher than the present technology unless it is highly subsidised. To save the environment from further pollution it is worthwhile to subsides at least the incremental cost involved in the implementation of the project.

15.4. The CFL dissemination program is consistent with the **Long Term Measures** component for *removing implementation barrier for technologies* as defined in the GEF Operation Strategy. The program is cost-effective. The unit cost of saving CO_2 emission is very near the range described in the GEF Operation strategy between US$ 5.30 and US$ 10 per tc.

15.5. With an incremental cost of Tk. 5340 million or US$ 15.58 mn. (alt. I, see 12) GHG emission can be saved to the tune of 2.64 million tonnes. Thus the abatement cost of CO_2 per tonne comes to Tk. 2023 or US$ 47. This is a financial cost and not net of benefits.

15.6. The incremental cost, net of taxes, comes to Tk. 3393 million or US$ 79 million (alt. II, see. 12). At this the abatement cost of CO_2 comes down to around US$ 30 per tonne of CO_2. If the dissemination cost is deducted, the incremental cost comes down to Tk. 2092 million (US$ 49mn.) and the per tonne CO_2 abatement cost to US$ 18 only.

15.7. The incremental cost, net of the value of saved electricity, is Tk. 150 million only (alt. III see. 12). At this the CO_2 abatement cost per tonne comes down to only 59 taka or US$ 1.37, which is much less than even the minimal set by the GEF.

15.8. Considering the environmental benefits that the project will entail the GEF may come forward with its support which will cover full of the incremental costs estimated in 15.7 above and part of the costs estimated in 15.6, so that the total grant remains with in the limit set in the GEF operation strategy.

Annex :1

	Watt	Life (hrs)	Cost ($)							
Incandescent bulb	60	1000	0.5							
Compact fluorescent light (CFL)	15	10000	20							
Comment : one needs 10 incandescent bulbs over the life time of 1 CFL										
Period	1	2	3	4	5	6	7	8	9	10
Cost of incand. Bulbs over the lifetime of 1 CFL ($)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Present value of cost stream of incand bulbs ($)	3.36									
Cost of CFL ($)	20	0	0	0	0	0	0	0	0	0
Differential cost ($)	16.64									
Energy consumption Wh										
Incandescent (60 watts x 1000 hrs)	60000	60000	60000	60000	60000	60000	60000	60000	60000	60000
CFL (15 watts x 1000 hrs)	15000	15000	15000	15000	15000	15000	15000	15000	15000	15000
Energy savings-Wh	45000	45000	45000	45000	45000	45000	45000	45000	45000	45000
Energy savings-KWh	45	45	45	45	45	45	45	45	45	45
$ savings @ 0.05$/ KWh	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25	2.25
Present value ($)	15.10									
Incremental cost over the lifetime of 1 CFL ($)	1.55									

* 8% discount rate is assumed.

PROJECT TITLE	:	**BANGLADESH** : Gas Based Power Generation
GEF FOCAL AREA	:	Climate Change
TOTAL PROJECT COSTS	:	US$ 8004 million + Gas Exploration & Transmission Costs
GOVERNMENT COUNTERPART FINANCING : Local	:	US$ 1314.13 million
Foreign	:	US$ 5282.18 million
Co-FINANCING	:	International Financial Institutions
EXECUTING AGENCY	:	Power Development Board (PDB)
ESTIMATED STARTING DATE	:	1999
PROJECT DURATION	:	20 Years

BACKGROUND

1. Country Background

1.1 The People's Republic of Bangladesh lies between $20^0 34^/$ and $26^0 38^/$ north latitude and between $88^0 01^/$ and $92^0 41^/$ east longitude. The country is bounded by India on the North and on the West, by the Bay of Bengal on the South, and by India and Burma on the East. The area of the country is 148,393 square kilometres. It is mostly a low and flat deltaic land with the exception of some hilly areas in the north-east and south-east and some high lands in the north and north-east. The country is also one of the most natural hazard prone countries of the world and is visited regularly by floods and cyclones, and occasionally by droughts.

1.2 In 1991 the population of the country was 111.4 million. The percentage of urban population was 20.1, the rest being rural. The density of population was estimated to be 755 per sq. km. The intercensus growth rate of population estimated by using adjusted population of 1991 census was 2.1 percent per annum. Under certain plausible assumptions, the population of the country is expected to reach 129.6 million by 2000 A.D.

1.3 Bangladesh has a few proven mineral resources viz. natural gas, coal, peat, limestone, hardrock, lignite, silica sand, white clay etc. The country has enormous deposit of natural gas. So far, 17 gas fields have been discovered from which natural gas is available for power generation, industrial and other uses.

1.4 In 1995-96 the estimated per capita GDP in the country was Tk. 5051 (at constant market price of 1984-85) or US$ 125 approximately. The per capita GDP at current market price is nearly double of this amount.

1.5 With a per capita national income of around US$ 250 Bangladesh is one of the poorest countries of the world. Agriculture is the single most important economic sector contributing nearly 35 per cent to GDP. Industries account for only 10-12 per cent of GDP, while the rest is contributed by services.

2. Sector Background

2.1. In Bangladesh current demand for electricity is about 2000 MW, whereas current supply is about 1800 +MW. 75% of the current power comes from gas based PPs, 15% from oil based PPs and the rest 10% comes from hydro-power.

2.2. Only about 10% of the HHs (57% of urban and 4.7% of rural HHs) have access to electricity. Domestic sector consumed 2315 GWh in 1993-94, which was about 38% of total power sold. Per capita consumption is about 600-800 KWh per year. The annual growth rate of HHs is about 1.8%.

2.3. Industrial sector consumed 2183 GWh in 1993-94, which was about 46% of the total power sold in the country. Industry contributed about 12% to GDP in the same year.

Table-1 : Annual Projected Demand

Demand Sectors	FY 1994 GWh	FY 2015 GWh	Annual Growth Rate
Urban Domestic	1686	5731	6%
Rural Domestic	629	1753	5%
Agricultural etc.	349	795	4%
Industrial	2813	14160	8%
Commercial	671	2778	7%
Total	6148	25604	

2.4. To meet the projected demand additional 8700MW of capacity to be installed by the year 2015.

2.5. Although the power generation is predominantly gas based, the system is constrained within the next 8 to 10 years.

2.6. Gas reserve as of 1995 : 10.3 Tcf.

2.7. Annual consumption for power generation : 112 Bcf.

2.8. Percentage of gas used for power generation : 46%.

2.9. At the rate, the country would be able to supply required gas for power generation up to 2005. Unless there is additional investment in gas drilling, exploration and transmission, the possibility of gas supply for base power generation is extremely limited. If that is so, the country has to give up the option of gas based power generation (Plan A) and choose the baseline option to imported fuel oil based power generation (Plan B).

2.10. Since it takes 4-5 years to complete the establishment of power plants, the decision making point is the year 2000, whether the country is going for adopting the Sufficient Gas Plan- A or the Constrained Gas Plan- B.

3. Project Goal

To increase electricity generation by keeping GHG emission to its minimum..

4. Project Objectives

4.1. To meet the present as well as future demand for electricity for industrial development and rural electrification of the country keeping the GHG emission to its minimum.

4.2. To reduce the import dependence of fuel and base our industrialization and economic development on indigenous resources.

4.3. To achieve economic development of the country through industrialization by meeting the demand (present and projected : Table-1) for energy.

5. Project Description

5.1. Establishment of 8800 MW gas based power generation capacities by the year 2005.

5.2. Setting up of transmission and distribution network to the rural areas.

5.3. Exploration of natural gas and expansion of transmission network to the newly established power plants before the presently operated gas-fields are exhausted.

5.4. Ensure supply of natural gas to the power plants which would reduce dependence on imported fuel.

6. The budget :

The total budget for the project is US$ 8105.48 million including local costs of US$ 1314.13 million. The detail budget is shown in Table-2 :

Table- 2 : Projected Financing and Budget (in million US $)

Foreign costs	95/96	96/97	97/98	98/99	99/00	00/01	½	02/03	03/04	04/05	Total
Generation	107.46	144.27	253.50	399.17	431.81	418.76	436.01	563.39	582.42	347.71	3684.50
T & D	102.26	139.84	145.17	171.03	177.53	165.51	174.15	183.25	178.34	160.99	1598.07
Total	209.72	284.11	398.68	570.19	609.35	584.27	610.16	746.64	760.76	508.70	5282.58

Local costs	95/96	96/97	97/98	98/99	99/00	00/01	½	02/03	03/04	04/05	Total
Generation	56.88	59.73	75.25	87.65	84.93	61.15	59.53	77.25	83.45	51.45	697.23
T & D	49.55	51.23	53.10	61.38	64.95	60.23	63.93	67.83	68.55	66.18	616.90
Total	106.43	120.95	128.38	149.03	149.85	121.38	123.46	145.08	152.00	117.6	1314.13

Total(F+L) costs	95/96	96/97	97/98	98/99	99/00	00/01	01/02	02/03	03/04	04/05	Total
Generation	164.33	212.15	355.60	547.60	604.48	583.93	627.00	843.03	911.28	568.13	5417.53
T & D	151.80	209.10	214.48	261.40	283.68	274.65	301.25	330.40	337.90	323.30	2687.95
Total	316.15	421.25	570.08	809.00	888.16	858.58	928.25	1173.43	1249.18	891.43	8105.48

Note :
Import duty of 20% has been applied to the CIF costs
VAT of 15% has been applied to the total import costs, including import duty and taxes.
Inter charges on funds used during construction = 6%.
Average annual inflation of 4% has been assumed for all costs.

7. Project Implementation :

i. Bangladesh Power Development Board (BPDB) is the designated implementing agency in Bangladesh;

ii. Private sector will be encouraged to invest in power generation activities;

iii. Generated electricity will be distributed by the Dhaka Electricity Supply Company (DESCO) and Rural Electrification Board (REB);

iv. DESCO and REB will be responsible for billing and collecting revenues at the current tariff rates;

v. Natural gas exploration will be undertaken by the Petrobangla/ BOGMC in collaboration with International Gas Mining Agencies.;

vi. Natural gas transmission and distribution will be undertaken by the subsidiary companies of Petrobangla

8. Project Sustainability :

Project Sustainability is envisaged due to the following reasons :

- Strong commitment by all the participating agencies
- Some private sector companies have already shown their interest in establishing 600 MW combined cycle capacities at Meghnaghat generating site

9. Economic Analysis :

Power is the lifeline of industrialization and economic development. Un-interrupted and stable power supply will attract local and foreign investment for assured return through industrialization. It is already known that cost of unserved energy in urban areas is about 0.43 $ KWh which is about 8 times than the usual charge.

From the economic point of view, the plan is one of the least -cost options the country now can choose between ,(Table-3) and it is environmentally more friendly than the other options.

Table-3 : Economic Benefits of alternative options

Benefit indicator	Baseline (B)	Mitigation A)	Mitigation (A)*
NPV (million $)	522.92	723.77	341.26
EIRR (%)	16.95	18.20	14.45

- If the costs of natural gas exploration, transmission and distribution as shown in Table-4, are included in Plan A

Note : NPV was calculated using 12% discount rate.

Table-4 : Natural Gas Exploration, Production, Transmission & Distribution (in million US $)

Items	1980-94	1995-2000	2001-2005
Exploration	215	78	37
Production	767	195	74
T & D	665	143	66
Total	1637	416	177

10. Barriers :

The following are the major barriers to the project.

i. The gas reserve in the country as of 1995 was 10.3 Tcf. So far, 17 gas fields have been discovered from which natural gas is available for power generation.

ii. Gas used for power generation at present is about 46 percent. Given the availability of gas, as of now, for power generation the system is constrained within the next 8 to 10 years.

iii. The meet the demand for energy as projected earlier (Table-1) an additional 8700MW of capacity will have to be installed by the year 2015.

iv. Further exploration of gas require additional investment in drilling, exploration and transmission of gas. This requires considerable amounts of funds in terms of both local currencies and foreign exchanges.

11. The Way to Overcome the Barriers :

The project is expected to overcome the barriers through the adoption of the following measures :

i. GOB, for the sake of industrialization of the country, will come forward with the relevant agencies (Petrobangla/BOGMC) for further exploration of natural gas.

ii. Private sector, both national and international, will be encouraged to invest in the fields.

iii. Some private sector companies have already demonstrated their interest in the field. This may be exploited further.

iv. Financial constraints may be overcome by GEF/UNDP supports.

12. Incremental Cost :

The incremental cost that may demand GEF support is made up of as follows :

i. All the taxes including VAT and interest are deduced from the total costs (F+L) as shown in Table-2;
ii. Average annual inflation rate over the life of the project is avoided;
iii. GEF support is an addition to the local total costs required;
iv. Calculated in the manner stated above the incremental cost which the GEF may provide comes to US$ 466 million only.

13. Rational for GEF Support :

i. Table-5 shows that if option `A' other than `B' is taken, it saves a total of 43.84 Tg CO2 emission over the life of the project.
ii. With a GEF support of US$ 466 million (see section-12) the per tonne cost of CO2 emission comes to US$ 10.63 only.
iii. The program is consistent with the **Long Term Measures** component for removing implementation barriers for technologies as defined in the **GEF Operation Strategy**. The unit cost of the proposed project is near the cost (US$ 10 Per tC) described in the GEF Operation Strategy. Thus the project, it seems, is worth of being funded.

Table- 5 :Global Environmental Aspects :

Case/ FY	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Baseline (B)	12.53	14.01	15.64	17.37	18.82	20.76	22.78	24.91	27.18	29.60	32.20
Mitigation (A)	12.53	12.96	14.22	14.88	15.67	17.26	18.21	19.68	20.93	22.02	23.61
change (B-A)	0	1.05	1.43	2.49	3.15	3.50	4.56	5.23	6.25	7.59	8.59
% Changes	0	8.13	10.05	16.74	20.10	20.30	25.04	26.57	29.84	34.46	36.39

A total of 43.84 Tg CO2 emission can be saved.

PROJECT TITLE		:	**BANGLADESH** : Solar Electricity with PV Systems
GEF FOCAL AREA		:	Climate Change
TOTAL PROJECT COSTS		:	US$ 145 million
GOVERNMENT COUNTERPART		:	
FINANCING :	*Local*	*:*	
	Foreign	:	
Co-FINANCING		:	
EXECUTING AGENCY		:	Power Development Board (PDB)/ Rural Electrification Board (REB)
ESTIMATED STARTING DATE		:	1999
PROJECT DURATION		:	20 Years

SOLAR ELECTRICITY WITH PV SYSTEMS
THROUGH POPULAR PARTICIPATION PROCESS IN BANGLADESH

BACKGROUND

1. Country Background

1.1. The People's Republic of Bangladesh lies between $20^0 34'$ and $26^0 38'$ north latitude and between $88^0 01'$ and $92^0 41'$ east longitude. The country is bounded by India on the North and on the West, by the Bay of Bengal on the South, and by India and Burma on the East. The area of the country is 148,393 square kilometers. It is mostly a low and flat deltaic land with the exception of some hilly areas in the north-east and south-east and some high lands in the north and north-east. The country is also one of the most natural hazard prone countries of the world and is visited regularly by floods and cyclones, and occasionally by droughts.

1.2. In 1991 the population of the country was 111.4 million. The percentage of urban population was 20.1, the rest being rural. The density of population was estimated to be 755 per sq. km. The inter census growth rate of population estimated by using adjusted population of 1991 census was 2.1 percent per annum. Under certain plausible assumptions, the population of the country is expected to reach 129.6 million by 2000 A.D.

1.3. Bangladesh has a few proven mineral resources viz. natural gas, coal, limestone, hardrock, lignite, silica sand, white clay etc. The country has enormous deposit of natural gas. So far, 17 gas fields have been discovered from which natural gas is available for power generation, industrial and other uses.

1.4. In 1995-96 the estimated per capita GDP in the country was Tk. 5051 (at constant market price of 1984-85) or US$ 125 approximately. The per capita GDP at current market price is nearly double of this amount.

1.5. With a per capita national income of around US$ 250 Bangladesh is one of the poorest countries of the world. Agriculture is the single most important economic sector contributing nearly 35 per cent to GDP. Industries account for only 10-12 per cent of GDP, while the rest is contributed by services.

1.6. The country being experiencing monsoon climate and being criss-crossed by innumerable rivers is endowed with plentiful supply of renewable resources of energy.

2. Sector Background

2.1. In Bangladesh the per capita consumption of energy is 176 kg of oil equivalent (KGOE), of which 112 KGOE (64%) comes from traditional sources (mostly biomass) and the remaining 64 KGOE (36%) from commercial sources.

2.2. The present installed electricity generation capacity of the country is 2908 MW. Of this indigenous gas based capacity is 2175 MW (75%), hydro capacity is 230 MW (8%), furnace oil based capacity is 170MW (6%) , diesel based capacity is 333 MW (11%). The system load factor is about 62%. The annual plant factor in FY 1995, based on the total installed generation capacity, was only about 42.40%. This low plant factor is due to derated capacity, outage of many units for long duration for rehabilitation and low system load factor.

2.3. The electricity demand in Bangladesh is characterised by sharp increase during the evening peak hours. The current supply of electricity in the country is about 1800 MW against the current demand of about 2000 MW. In FY 1994 the urban domestic, the rural domestic, the industrial and the commercial sectors consumed 1986, 629, 2813 and 671 GWh of electricity respectively.

2.4. With its economic growth and development the demand for energy in the country will grow further presumably, at an increasing rate. On a very conservative estimate depending on historical data for electricity consumption growth rates in different sectors and making adjustments for changing future economic conditions, one may forecast the demand for electricity in the country for a future date. Thus calculating only a 6% annual increase in urban domestic sector, 5% in rural domestic sector, 8% in industrial sector and 7% in commercial sector (see Table-4 in BPDB/ADB, Power System Master Plan, Bangladesh, Vol. 2) the respective sectoral demand will come to approximately 7450 GWh, 2191 GWh, 19824 GWh and 3750 GWh in 2020. To satisfy this huge demand Bangladesh will need to establish new generation plants which will involve huge costs, consumption of precious natural gas and/ or petroleum etc. which are all imported at the hard earned foreign exchange.

2.5. Added to the above, massive rural electrification program of the Government of Bangladesh demands further increase of power generation in the country. So far electricity has reached about 30% of rural areas, but less than 10% of the households could get it. The Government determined objective is to electrify all the 80,000 villages in Bangladesh by 2000 AD. The Rural Electrification Board (REB) therefore, has undertaken elaborate program to achieve the target. The electricity connections in villages are made from the grids which use conventional sources of energy such as natural gas, diesel and furnace oil which, as said earlier, devour precious natural gas, a source of petrochemical and fertilizer on the one hand, and causes drainage of hard-earned foreign exchange for import of petroleum, on the other. Moreover, there are remote areas and islands where supply of electricity from the grid is either very expensive or almost impossible under the present circumstances.

2.6. One way of facing the electricity generation problem is to look for an alternative but affordable system of generation. The photovoltaic system is a good, hazardless and environment friendly system. This system uses solar energy for generation of electricity. It does not require any kind of conventional fuels. Since solar energy is available everywhere in Bangladesh this new technology may serve as a great booster for rural electrification.

3. Experience in Bangladesh

3.1. With a view to experimenting this new technology under the climato-socio-economic conditions of Bangladesh, REB has undertaken a solar PV pilot project in some isolate islands of Narsingdi district. The project is to be completed soon.

3.2. In the Narsingdi solar PV project area five types of PV systems consisting of 1370 units are being delivered for experimenting to 950 consumers. This is shown in Table-1. System I consists of a 8-watt lantern, 3-watt incandescent lamp and 6 watt peak (wp) module. In System II, there is a 12-volt (60 AH) battery to light two 8-watt fluorescent tubes and in System III, there are two 12-volt batteries (60 AH each) to light two 8-watt and one 13-watt fluorescent tubes and also to run a fan and a PV/ VCP. The batteries for these systems are charged at solar charging stations. Three solar charging stations have been set up in the project area.. System IV has one 46 wp module to charge a 12-volt (100 AH) battery which will run the same type and number of appliances as in System III. In System V, two 46 wp modules will charge two 12 volt (100 AH) batteries which will light one 8-watt and two 13-watt fluorescent tubes and also run one fan and one TV/VCP.

3.3. Under this pilot project PV systems have already been installed at one rural health clinic for running fans, lights and refrigerators. Same systems are being installed in another clinic.

Table-1 : PV System in the REB Pilot Project in Narsingdi

Type	System I Lantern	System II	System III	System IV	System V
Unit supplied	400	380	275	190	125
Module (Watt peak)	6	Charged at PV charging station	Charged at PV charging station	46	2x46
Battery (no. x volts x amphours)	6V x 3.2AH	12V x 60AH	2 x 12V x 60AH	12V x 100AH	2 x 12V x 100AH
8 W fluorescent	1	2	2	2	1
3 W incandescent	1	-	-	-	-
13 W fluorescent	-	-	1	1	2
Fan	-	-	1	1	1
Socket	-	1	1	1	1

4. Project Goal

To lower GHG emission by lowering the burning of kerosene, diesel and biomass at the rural households level.

5. Project Objectives

The primary objectives of the `Solar Electricity with PV System' in Bangladesh are to :

i. To generate/increase the availability of affordable electricity to the isolated rural people of Bangladesh to improve their quality of life.
ii. Catalyse rapid penetration of solar PV systems within the framework of a least-cost rural electrification (RE) program;
iii. Provide solar electricity to remote and isolated areas where the cost of providing grid electricity will be exorbitantly high;
iv. Facilitate popular participation and participation of the private sector including cooperatives and NGOs in advancing the commercialization of solar PV systems through the creation of a sustainable market framework;
v. Promote environmentally sound energy resource development in Bangladesh and reduce rural energy dependence on traditional sources, notably biomass;
vi. Demonstrate the usefulness and techno-economic viability of PV systems under the climate-socio-economic conditions of remote and isolated areas where grid electricity will not reach in the near future;
vii. Study the effects of the new PV technology on the socio-economic upliftment of the rural consumers and possible further generation and dissemination of solar electricity through PV technology.

6 Output

The major outputs of the introduction of the photovoltaic system of electricity generation in Bangladesh are the following :

i. In Bangladesh, as elsewhere, the electricity connections are made from the grids which use conventional sources of energy such as natural gas, diesel and furnace oil, which are associated with GHG emission. The system is also highly costly. Photovoltaic system uses solar energy for generation of electricity and therefore is free from GHG emission. The system is also less costly compared to the grid system.

ii. It is estimated that the PV system, if implemented, will save Tk. 200 million annually in the from of saved consumption of kerosene, purchase of indigenous lighting equipment like, Kopi, hurricane lamps, hajjak lamps etc.,

iii. In addition to the above GHG emission will also be saved as the system itself is hazardless and environment friendly ; and if implemented, will save Kerosene burning for lighting, which emits CO_2

7. Project Description

The project will consist of the following major components :

i. Solar electricity will be provided in remote and isolated areas where the cost of providing grid electricity will be prohibitively high. Initially, investment will be made to support the sale and installation of about 100,000 solar home systems in about 5 selected areas. One criterion for selection of a location will be the availability/formation of potential village organization which may act as a vehicle for popular participation leading to the sustainability of the project. Based on these, offshore islands, islands in the rivers and remote and inaccessible areas in the main land will be selected.

ii. The project area will be provided with the facilities for Solar lighting with arrangement for TV, Radio and Fan

iii. The project may initiate its activities by July, 1998 and with a provision of 6 months for preparation etc. the actual installation of the system at the consumes home may be started from January, 1999. With a dissemination rate of 10000 units per year the project may be completed in 10 years.

iv. The installation of an SHS unit the required equipment are (a) Solar Module (100PW), (b) Battery (100AH), (c) Charge regulator, (d) Mounting structure, (e) Installation kits, and (f) Cables and connecting gadgets. Most of those equipment are to be imported.

Table- 2: The Budget : Cost for installation of 20000 SHSs over 10 years

one locality

Components	Total costs (million Taka)
1. Equipment :	
i. Solar Module (10pw)	440
ii. Battery (100AH)	360
iii. Charge Controller	120
iv. Support Structure	40
v. Cables and Connecting Gadgets	200
2. Tax on imported items (7.5%)	69
3. Labour (skilled)	6
4. O& M	5.5
Total	1240.5 (or US$ 29 million)

8. Budget for the Project

The total capacity building cost per 20000 Solar Home System (SHS) in one of the five localities over the life of the project (10 years) at 1997 constant price comes to Tk. 1240.5 million or US$ 29 million (US$ 1= Tk. 43)as shown in Table-2

9. Project Implementation

i. The project will be implemented either by the Power Development Board (GOB) or by an NGO which has experience in PV systems, under the overall supervision of the relevant department of the Ministry of Energy and Mineral Resources, or by the both;

ii. Rural Electrification Board (REB) which has already undertaken a solar PV project in some isolated islands of Narsingdi district will be a partner to the project and will sell and install the SHS units through its associated bodies/ organizations, or approved suppliers / dealers.

10. Major Barriers

The following are the major barriers to the sale and installation of the SHS technology :

i. High prices of the components compared to the cost of fuel plus equipment now being in use in target villages (kerosene, kopi, hurricane-lamp etc.);

ii. Lack of established high-volume supplier-dealer chains;

iii. Lack of availability of funds.

11. The Way to Overcome the Barriers

The project is expected to overcome the barriers through adoption of the following measures :

i. Designing of installment payment mechanisms such that it takes into consideration the rural households' cash constraints;

ii. Facilities of bank credit may be created for the customers so that they can deposit the required installation fee quickly and easily;

iii. Provide term-credit from commercial banks to SHS suppliers/ dealers;

iv. Support a " first-cost buydown" in the range of Tk. 4000 - 5000 (US$ 90 - 120) per SHS sold from the GEF grant.

12. Past Experiences and Lessons Learnt

Under the overall supervision of Rural Electrification Board (REB), Narsingdi Palli Biddut Samity (NPBS-1) has installed over 400 PV systems in some river islands in the district of Narsingdi about 45 kms away from Dhaka. These systems have been installed with the assistance from BCAS and the Associate Resources Management Company (ARMCO).

From the opinion polls conducted by BCAS personnel, it appears that all the consumers, who have been provided with systems 2,3 and 5 (see Table-1) are satisfied with the performance and the services. One consumer has already made a comment saying that his PV system is better than the grid, because the entire system is under his control and there is no fear of unwanted blackout because of load shedding. He knows how to plan the duration of different appliances to get the maximum benefits. This has resulted into increased interest of neighbours to get the PV connection. People have already started coming to the NPBS for making the security deposit.

13. Sustainability

The sustainability of the project is enhanced by :

i. Strong support from the Government of Bangladesh and the relevant departments of the concerned Ministry;

ii. Strong commitment of the REB and its affiliated organizations/ agencies;

iii. Commercial bank credit at easy terms to rural households to pay for the installation and services of an SHS unit;

iv. GEF subsidy till the system becomes self-sufficient in terms of finance and a demand-driven market for the system is created in the target areas.

v. Self-control of the system by the consumer and an uninterrupted energy supply (free from unwanted blackout due to loadshedding under the grid system) as needed should make the system highly acceptable and further its sustainability.

14 . Economic Analysis

The Government of Bangladesh has undertaken a program of rural electrification and has set the target to electrify all the 80000 villages in the country by 2000 AD. The Rural Electrification Board has, therefore, undertaken elaborate program to achieve the target. There are two alternative ways to achieve it, viz. (I) supply of electricity by the conventional grid systems and (ii) establishment of solar PV system for power generation.

The conventional grid system is highly costly. The minimum normal expenditure that is required per consumer under the system is Tk. 61050 or US$ 1420 (estimated from Annex-1). This does not include internal wiring or fixture costs. If the location is an island and/or a remote and isolated area where accessibility is not easy, the installation cost of a PBS, the grid and cables etc. will multiply. Under the circumstances, keeping political decisions aside, the system may not be economically viable so far as only lighting is concerned.

One benefit of the grid system however is that once the system is installed with a considerable capacity of electricity supply, electricity may become available for activities other than lighting and comforts alone. Thus electricity may be supplied from the installed power sub-station for rural industrialisation, intensive agricultural production through intensive irrigation by DTWs etc. In such a case although one may argue that the grid system may be economically acceptable, the question remains whether or not a poor country like Bangladesh can afford to make such huge investments in the short-run.

Electricity generation under the grid system is done by conventional fuels like natural gas, diesel, furnace oil etc. Construction of gas turbines at isolated remote islands for electricity generation is highly costly and thus may not be cost-effective either. Other sources of energy particularly, petroleum etc. are all imported and incur unaffordable costs. So, large-scale distribution of energy through the grid system in isolated rural areas of Bangladesh seems to be an uneconomic, almost impossible, proposition. In addition, the system is not environment friendly. Burning of gas and/or petroleum emits GHG and thus pollutes the air.

Option (ii) that is, generation of solar electricity through PV system is good, hazardless and environment friendly. It does not require any kind of conventional fuels and therefore free from GHG emission and creation of health or environmental hazards. It can also be easily installed in remote areas were normally the grid cannot reach.

However, the PV system is not a very cheap alternative. Its cost is also considerably high as is in case of other renewables. Thus, the cost per SHS is around Tk. 50000 (US$ 1163) which apparently is high and definitely is unaffordable for a poor rural household. But if rural electrification for lighting is the commitment of the Government, the system is a better alternative both economically and environmentally.

Financially, the PV system costs Tk. 11000 less than the grid system per consumer. It also saves the expenditure required for kerosene and the kerosene lamps, hurricanes etc., which on an average amounts to Tk. 2000 per household per annuam. Thus the economic benefit stream of the PV system will include the saved expenditures on kerosene etc. under the indigenous method of household illumination. The comparative advantage of the system over the alternative I should also be recognized.

NAP estimated in the manner stated above indicates that the project is economically viable (Annex-1).

In addition to the direct economic benefits the implementation of the project will recon many other indirect benefits in the fields like, education (reading and writing at night), recreation and awareness building through electronic media, very small scale productive activities at night under the electric light better security from theft and such other benefits associated particularly with better human.

15. Incremental Cost

The incremental costs of the project are made up of the following components :

i. Tk. 892 million (US$ 20.8 million) for capacity building;

ii. An estimated Tk. 500 million (US$ 11.6 million) for the "buy down" of 100000 SHS units; which may be bone by the users.

iii. In addition the GOB will provide Tk. 53.8 million (US$ 1.25 million) for the support of a small "Project Support Unit", to be established under the Ministry of Energy.

16. Risk

The current market condition in respect of solar PV technology are characterized by a " high price low volume" equilibrium, while for sustainability a " low price high volume" equilibrium is necessary. This means that sustainable expansion of solar systems in rural areas are not amenable to single-problem solution. A multi-pronged strategy taking into account affordability of the rural households and terms and conditions under which the delivery is made is required. It is well known that for any new technology post-installation service is a necessity to show the reliability of the systems and as such effective post-installation monitoring and services must be ensured.

17. Rationale for GEF Support

17.1. In the rural areas lighting sources include candle, flash light and kerosene lamps which are highly polluting and dangerous. This lamp produced dim light which causes eys-strain. Moreover, kerosene lamps produce fumes and dust particles, which are inflammable and harmful to health. These fumes and dust particles make the household articles dirty. Solar lighting reduces harmful emission by decreasing the use of kerosene and diesel on the one hand and reduces dependence on imported oil, the other.

17.2. The Global environmental objective of the project is to mitigate emission of carbon dioxide. As stated above lighting in the rural areas is done by kerosene directly or diesel and natural gas-based power generation. The total emission is of the 1.5 million tonnes annually. It is expected that this project will help abate this emission.

17.3. The solar Energy Generation program is consistent with the Long Term Measures component for removing implementation barrier for technologies as defined in the GEF Operation Strategy. The program is cost effective. The unit cost of saving CO_2 emission is much less than the range described in the GEF Operation Strategy between US$ 5.30 and 10 per tc.

17.4. It is anticipated that the project will mitigate about 1.5 million tonnes of CO_2 annually. Thus with a GEF grant of Tk. 112 million (incremented costs), the GHG abatement cost will come to Tk. 75 or US$ 1.75 per ton CO_2.

Annex-1 :

Solar PV System

Beneficiaries: 20,000 hhs

(in each of the 5 locations)

Project Life: 10 years

Costs and Benefits

Characteristics	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
A. Cost Stream (Grid system : Alternative I)																				
1. Grid (not cost.)																				
I) Investment for PBS	350	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ii) Generation & transmission	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77	77
iii) Operating expenditure	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
iv) Connection from grid	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
v) Operation & maintenance cost	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
vi) Total cost	437.1	87.2	87.3	87.4	87.5	87.6	87.7	87.8	87.9	88	88.1	88.2	88.3	88.4	88.5	88.6	88.7	88.8	88.9	89
vii) PV of costs	303.47																			
B. Cost stream (PV System : Alternative II)																				
1. Equipment:																				
I) Solar Module (100pw)	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
ii) Battery (100 AH)	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
iii) Charge Controller	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
iv) Support structure	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
v) Cables etc.	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
2. Labour Costs (skilled)	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6
3. Operation & Maintenance Costs	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2
4. Total costs	100.7	100.8	100.9	101	101.1	101.2	101.3	101.4	101.5	101.6	101.7	101.8	101.9	102	102.1	102.2	102.3	102.4	102.5	102.6
5. PV of costs	126.03																			
C. Saved cost of kerosene etc.																				
i)Kerosene & indigenous costs	4	8	12	16	20	24	28	32	36	40	40	40	40	40	40	40	40	40	40	40
ii) PV of saved costs	11.21																			