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MICRO POWER COMPANY: COMMUNITY BASED RENEWABLE ENERGY ENTERPRISE FOR RURAL BANGLADESH

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Abstract Energy demand in Bangladesh will be more than double by 2020. With commercial energy increasing by 400% 53% of the present supply of energy comes from traditional fuels and the remaining from commercial sources. This constitutes a continued transfer away from traditional energy supplies towards commercial energy, that has been characteristic of Bangladesh's energy development since the 1980's. In rural Bangladesh, energy demand is mostly for household cooking which is almost completely supplied from biomass resources. When viewed at a national level, the utilisation of biomass fuels for household cooking comprises roughly half of the total energy balance of Bangladesh. Thus, the combustion of biomass for household cooking is incredibly significant in regards to energy sustainability in Bangladesh. In this paper prospects of a diversified, decentralised renewable energy based energy enterprise 'Micro Power Company' (MPC) has been examined which can offer a sustainable alternative for the provision of energy in rural Bangladesh. Extension of microcredit supports to the rural people will, in one hand, meet the economic needs for energy and social and environmental upgradation of their lives, on the other .

Keywords: Rural development, Renewable energy, Microcredit.

Introduction:
The primary environmental concern of energy production today is the protracted effects of global climate change. Indeed the likelihood of global warming, coupled with the effects of political and economic globalisation, appear to be moving nations to recognise our social and environmental interconnectedness, more than ever before. This necessity to identify a path of sustainable development "that meets the needs of the present without compromising the ability of future generations to meet their own needs"[11] is paramount. Although the actual framework is a highly debated issue, some principles of sustainable development that are emerging are - the recognition of community that encompasses local management of local resources, a commitment to social equity and a respect for the environment. In an energy context, this implies the development of energy systems supplied from small, varied, decentralised and locally managed renewable sources.

The developing countries, in particular, related to the energy debate, generally exhibit characteristics, of:

- large growth rates in energy demand, especially within rural areas.
- vulnerability to climate change, especially of agricultural systems.
- dispersed rural populations, largely unmet by centralised energy systems.
- renewable energy resources, largely under-utilised within rural areas.
- the limit to growth, implied by environmental restraints

ENERGY SCENARIO IN BANGLADESH

Country Background
The population of Bangladesh, as per 1991 census, is estimated to 111.4 million, at a density of 755 persons per square km.[2]It is anticipated that by 2020, the population will increase to 170 million, at a density of 1150 people per square km.[3] 80% of the population is rural and by 2020 it is predicted that almost 50% of the population will be located within urban centres[4]. Such massive urban growth raises questions as to the sustainability of Bangladesh's development - thus necessitating action to either support, or redirect, this growth.
The national GDP of the country is estimated at US$ 340, with a recent assessment by the World Bank[5] placing 36% of the population as very poor and 53% as

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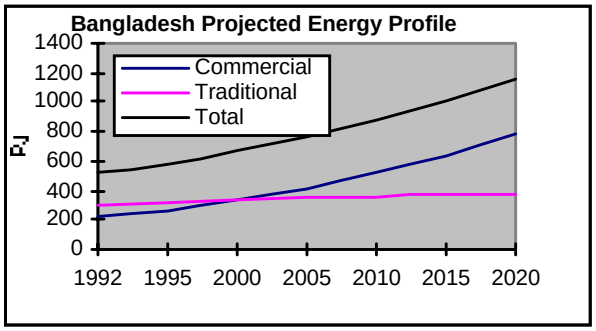
poor, with the incidence of poverty in rural areas significantly higher than in urban areas. The decline in poverty experienced by Bangladesh in the 90's may be in part due to the efforts of the Grameen (rural) Bank and other NGO's and their micro-credit programs which have been focused on the poor. The success of such microcredit enterprises is evident in their performance. Grameen Bank is now having more than 2.3 million borrowers, 94% of whom are poor women, located in 37,000 of the 64,000 villages of Bangladesh. In June 1997 total lending grossed US$2 billion at a 95% repayment rate[6]. This principal of micro-credit banking has spread throughout the developing, and the developed countries as well. The Grameen Bank and similar agencies have focused on providing credit services to marginalised individuals, particularly women.

Energy

Energy is part and percel of human life and has become a fundamental component of development activity. Bangladesh is regarded as one of the low energy utilisers and per capita energy consumption is one of the lowest in the world. In Bangladesh, at present 53% of total energy consumption is supplied from traditional fuels resources, with the remaining 47% from commercial sources[7]. The continued transfer away from traditional energy supplies, towards commercial energy has been the characteristic of Bangladesh's energy development since the 1980's. In an extension of this trend, demand forecasts for the period 1992-2020 reveal that the energy demand in Bangladesh will more than double by the end of 2020, with commercial energy increasing by 400%, and non-commercial energy displaying an increase of just 45%.[8]



Traditional Energy Resources

Although the use of traditional energy is declining, as a percentage of total energy use in Bangladesh, the traditional forms of energy still predominate within the rural areas of Bangladesh. It has been estimated that 88% of the rural energy demand is for household cooking, this being almost completely supplied from biomass resources. When viewed at a national level, the utilisation of biomass fuels for household cooking comprises roughly half of the total energy balance of Bangladesh. Agricultural residues are significantly the greatest resource of biomass energy in rural areas, with paddy straw contributing a significant amount of this total. This high usage of agricultural residues as a fuel source, rather than as recycled organic matter for soil conditioning, is impacting soil quality and establishing greater dependence on synthetic fertilizers.

Commercial Energy Resources

The large growth in the demand for commercial energy predicted for Bangladesh, anticipates that the demand will be met through expansion of the natural gas sector. The gas sector has expanded rapidly since the early 70's, and now accounts for 60% of the countries commercial energy supply - with the balance being met by imported liquid fuel (32%), coal (4%) and locally produced hydro energy (4%).[9] The availability of low cost natural gas has enabled the expansion of (1) the power sector, and (2) the fertiliser industry, to a point where they now consume 43% and 34% respectively of the total gas supply. The remaining 23% being consumed by industrial, commercial and residential consumers.[10]

Only 16% of the total Bangladesh population has access to electricity and a rural access is less than 5%[11]. This places Bangladesh's electrification rates amongst the lowest in the world. The responsibility for the generation and distribution of electricity is lying with public sector agency Power Development Board (PDB). The Rural Electrification Board (REB)
another public sector agency purchases power from PDB and distributes in rural areas.

The major attributable cause for these low electrification rates is due to PDB's poor operating performance resulting huge losses which often limits further investment in new power stations. PDB is the country's largest loss-maker in terms of capital employed. Given the huge financial losses incurred by the Government of Bangladesh in power sector, electrification is recognised as highly subsidised industry. Identifying the extent to which this industry is subsidised (per KW.hr), may be beneficial in framing the extent to which Government should financially subsidise the development of 'alternative electrification strategies'.

Potentiality of renewable resources

Wind*:* The wind resource is one of the potential energy sources specially for the coastal and off-shore islands of Bangladesh, most of them having no access to electricity or gas supply system. However, application of wind energy technologies needs a systematic and proper assessment so far been the major obstacle towards wind energy projects. In recent years GOB has taken interest to assess the potential of wind energy in the south-eastern coastal areas of the country. It appears from one of the studies that, wind pumps can be commercially used for irrigation by replacing the existing diesel

pumps. It may further enhance the future extension of shrimp hatcheries and shrimp processing units in those areas, where fishery is the main occupation of the local community.[12]

Solar: The only long term irradiation data available within Bangladesh comes from the Renewable Energy Research Centre (RERC) at Dhaka University shows that average irradiation rate (4.7 kW.hr/m^2/day) which is available throughout the year can be suitable for generation of electricity using PV cells. Recently the GOB has removed the import duties on solar panels, as part of the Government policy to encourage the use of renewable energy.

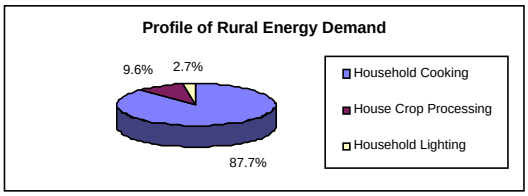
Energy Storage Batteries: Rahimafrooz, a leading battery manufacturing company of the country is producing large quantities of deep cycle batteries for export. Due to lack of local demand they are not available on the local market. Rahimafrooz manufacture deep cycle batteries based on the placement of a specific order, which explains why deep cycle batteries are unavailable in the local market. Similarly, charge controllers and DC fluorescent lights are also being manufactured locally.

Biomass*:* The Institute of Fuel Research and Development (IFRD) of the Bangladesh Council of Scientific and Industrial Research (BCSIR) has been working on the R&D of improved efficiency cookstoves and anaerobic digesters for several years. For last few years these technologies are being disseminated in some thana head quarters of the country as demonstration projects. In many regards the technology is well developed but could propagate extensively within vast rural areas.

Use of Renewable Energy as an Alternate Energy Option

The specific aim of this paper is to generate a framework that enables the beneficial characteristics of available renewable energy sources to be brought together with the demand side, and supply side technologies by integrating the three major development players, the Government, market and the community:
- to meet the immediate energy development needs for rural Bangladesh villages
- by managing readily available *local resources* by the communities

The energy needs of rural Bangladesh villages, and the resources available to meet those needs, can be initially framed by investigating the current energy utilisation patterns. This provides some insight into the 'energy values' of the end users, however, the development still requires further elaboration.



This energy demand profile shall form the basis for our exploration of possible policy reforms to promote the sustainable utilisation of energy within rural Bangladesh. ie. (1) Household Cooking, (2) Household Crop Processing, and (3) Household Lighting.

Household Cooking

As identified above, the primary energy requirement - with its very substance magnified by its need for subsistence - is that of *Household Cooking*. This is further magnified by the fact that household cooking, supplied from biomass, comprises 51% of Bangladesh's total energy supply. In this regard, it is possibly fair to say that no significant reforms in energy sustainability can occur without addressing the household cooking process. Rural household cooking needs are presently met through the combustion of biomass (agricultural residues, wood fuel, wood waste and dried dung) within traditional cookstoves. Although these are essentially 'renewable' and 'carbon neutral sources', the low efficiency of utilisation and their subsequent depletion, provides a unique opportunity for renewable energy technologies.

The renewable energy technologies, to meet household cooking needs, using locally available resources, are:
(a) improved efficiency cook stoves, or
b) anaerobic digesters for producing biogas.

A variety of designs have been developed so far by Bangladesh Council of Scientific and Industrial Research (BCSIR). These technologies are capable of combusting traditional fuels (ie. paddy straw and other agricultural residues) with efficiencies of between 50-70%. This signifies an improvement of a factor of ≈4 over and above the efficiency of traditional stoves (10-15% eff.). At an extremely hypothetical level, assuming an uptake by 50% of the population of the improved efficiency cookstoves, the total energy requirement of Bangladesh could be reduced by 25%. Furthermore, as a quality of life issue, the improved efficiency cookstoves offer the potential for (a) the reduction of time and effort in collecting fuels, (b) the reduction of smoke and fumes enhaled during cooking. As a broader sustainability issue, the greater efficiency of fuel utilisation offers the opportunity for a greater percentage of agricultural residue to be left in the fields, adding necessary nutrients to the soil.

Anaerobic Digesters: Anaerobic digesters have undergone significant R&D in Bangladesh and in last

couple of years only a few thousand digesters have been installed in over 128 thanas (of total 460 thanas) of Bangladesh. Still this technology has lot more potential to contribute significantly on national energy sustainability. The 'digested sludge' produced as a waste product of the anaerobic digestion process is also a high quality fertiliser which can reduce dependence on synthetic fertilisers. This can be a key strategy for reducing greenhouse gas emissions and promoting sustainability of agro-farming.

Household Lighting

The provision of energy for household lighting, is considered foundational in enabling to raise socio-economic conditions of the rural people. The supply of lighting within households offers opportunities for residents to better meet their educational, economic and social needs. It is well accepted that the lighting provided by electricity is more stable and of higher quality than that which is available from gas, kerosene, candle or the burning of biomass. 'A PV-CFL system is some 100 times as efficient as kerosene and a half-million times more efficient than candles' at providing lighting[13]. PV generation technologies are generally most appropriate for providing electricity to small and remote energy demands.

Given the renewable energy resources available throughout rural Bangladesh, households to meet the lighting needs, as well as other ancillary needs, it is proposed that electricity generation shall be based on the generation from PV panels.[14] Such applications best utilise the low power energy supply and low maintenance characteristics of PV cells.[15]

The distribution of electricity is generated through PV panels is generally approached utilising one of three following distribution systems either through: (1) Solar Home Systems (SHS) (2) Grid Connected Systems or (3) Battery Charging Stations.

The major drawback of the Solar Home System is the high initial investment required to finance the panels, batteries and demand side equipment. Grid systems incur energy losses in both the conversion and distribution networks and require large capital investments. Although limited by size and charge capacity of the batteries, the number of cycles and inappropriate equipment, transportation of batteries to rural communities of the country as a means of electrification gives credence to its relevance.

PROJECT COSTING

1. Cooking

The combustion of biogas in low pressure gas burners [eff. = 40%] necessitates 1 m^3/day of methane, to meet these daily household requirements. In order to provide greater flexibility, digesters capable of generating 2 m^3/household/day have been nominated. This equates to the production of 5660 MJ/year, which can be produced utilising the dung of 5 cows [Approx. 20% of households have more than 4 cows, and a further 30% have some cows].

Costing for supplying of biogas to 50 households is estimated bellow:

Qty	Descrip-tion	Unit Cost	Total Cost
50	6.5 m^3 Biogas Digesters	Tk. 14,000-	Tk 700,000-
50	Low pressure Biogas burners	Tk 250/-	Tk 12,500/-
50	Supply lines	Tk 250/-	Tk 12,500/-
			Tk 725,000-

The cost of an anaerobic digester system is estimated to be Tk14,500/- part of which (Tk5,000/-) is to be subsidised as an extension of on-going incentive program by GOB for dissemination of biogas technology in rural areas.[16] And the rest to be made available to the household consumers through community microcredit facilities, arranged by the proposed village based energy enterprise Micro Power Company (MPC). Considering the average 8 years life of the digesters the cost of the gas will be Tk. 95/-per month or Tk 20/- per week.

2. Electrification

The design loading within an average household has been estimated to be 0.112 kW.hrs per day, which is sufficient to run two low power lights, and a fan, for several hours per day. A 100 A.hr battery can supply the electrical energy necessary to run this system for 5 to 6 days.[17] It is proposed that a charge controller built into the battery will protect it from the damage that occurs if the battery is discharged beyond 50%.

Taking into account losses in panels and batteries, a 70W PV Panel can supply the energy needs of 2-3 households, depending on usage and the time of the year. Therefore, conservative design loading can be equated to one 35 W panel per household, with

2 x 70 W panels capable of recharging a battery in a day. Therefore, estimates are based on 20 x 70 W panels, with the capacity to recharge 10 batteries/day i.e 40 to 60 batteries (average 50 batteries) within an exchange, recharging system.

The cost structures at the individual household and at community level (for 50 households) are as follows:

Qty	Descrip-tion	Unit Cost	Total Cost
50	100 A.hr Batteries	Tk. 8,500/-	Tk 425,000/-
50	Battery Charge Controllers	Tk 1,500/-	Tk 75,000/-
100	8W 'DC' Fluorescent Lights	Tk 500/-	Tk 5,000/-
	Total	Tk 10,500/-	Tk 505,000-

The cost to the households of a battery electrification system is estimated to be Tk10,500/-, with a total of Tk 505,000/- can be easily made available through community financing mechanisms.[18]

Operating cost of Household Battery System (HBS):

Descript ion	Cycl Time	Unit Cost	Cost/ Month	Cost/ Year
Fee for battery recharg e	5 days	Tk 15/-	Tk.90/-	Tk 1,080/-
Replace ment of ballast in 'DC' light	5 yrs	Tk 200/-	Tk 3.3/-	Tk 40/-
Replace ment of battery (1000 cycles)	14 yrs	Tk 6,000 /-	Tk 35/-	Tk 420/-
			Tk 128.3/-	Tk 1,540/-

The operating cost of the system for each household is Tk 1,540/- per year, or Tk 128/- per month.

Operation, management and return on investment of the recharging stations will be the responsibility of the Micro Power Company (MPC), a village based small energy enterprise. Given the 'showcase' status of this project it is proposed that the Government of Bangladesh (GOB) or NGOs like Grameen Bank, BRAC or any other development agencies can initiate the uptake of rural energy program through 'soft loans' or grants to the MPCs.

Purchase Cost of 'PV' Recharging Station:

Qty	Item	Cost/Unit	Total Cost
20	70 W PV Panels	Tk 22,000/-	Tk 440,000/-
1	Charg-ing Station Contro-ller	Tk 15,000/-	Tk 15,000/-
1 Set	Cables	Tk 10,000/-	Tk 10,000/-
			Tk465,000-

Rate of Return on Investment of Recharging Station:

Description	Tk	Tk/year
Battery recharge (20 batteries/day)	+Tk 15/- battery	+Tk 109,500/-
Salary for 2 Operators	-Tk 1000/ month	-(Tk 24,000/-)
Maintenance of Charging Station	-Tk 1000/- year	-(Tk 1,000/-)
		Tk 84,500/-

For an initial investment of Tk465,000/- , received as soft loan from GOB or donor agency @ 0% interest, and a rate of return of Tk 84,500/- per year; the pay back period is approximately 5.5 years.

For a guaranteed 25 years life offered by the major manufacturers of solar panels, and a rate of return on investment of 5.5 years, the investment in 'PV' recharging stations appears to be a viable development opportunity for local community based small power companies.

Affordability by the rural households

The electrification with recharging of batteries and supply of biogas from digesters can occur within community with conveniently available local resources. The successful dissemination of batteries within households will be the primary step towards the integration of any of the distribution systems identified above. For the foundation of household energy system the financial and technological resources necessary to integrate solar panels for charging of batteries, and setting up of anaerobic digesters, into the systems is minimal and can be readily done within the existing infrastructures and resources. Under the existing microcredit program of the rural NGO's like Grameen or BRAC 'micro-power companies' (MPC) can be established as a community business enterprise to supply battery charged electricity for lighting and other low energy consumption domestic uses and gas for cooking.

The provision of energy supply services by the local MPC's will be an efficient means of maintaining reliable services and this community based approach will ensure in avoiding illegal connections and non-payments of bills for the energy consumed.

Unlike urban people of the country, the rural people are generally comparatively in disadvantaged position in terms of accessibility to energy resources as well as to afford to get for improving the living standards. But availability of resources alone cannot guarantee accessibility due to limitations of their affordability. For that there needs a comprehensive and rational development strategy based on economic and social equality and justice. All the development stakeholders viz. the Government, the community and the market must play a definite role to that purpose.

The Government, as a regulatory body has to facilitate the development process by framing necessary policy framework and providing physical and technical assistance to the program. Financial subsidy and tax incentives for the community based MPCs will help the companies to stay in business and also accelerate government's other rural development programs.

The success of microcredit programs in rural Bangladesh, as tool to help alleviate poverty has brought the opportunity to develop micro-enterprises (i.e., very small businesses) at a rural level. They have been increasingly identified as a key component in job creation and the raising income level of the rural people. The process of lending to develop MPC's within community, will enable to diversify and develop other 'community development' activities and create the basis for development of societies with equitable access to dignified living conditions for all.

Conclusion

In respect to recent forecasts of world energy consumption and global climate change, it is suggested that developing countries such as Bangladesh are particularly vulnerable. This is primarily due to their location in the middle of a growth and sustainability nexus. Where the need to foster large growth rates in energy supply just to meet basic human needs is only too obvious.

It is therefore maintained that developing countries, such as Bangladesh, are best served by attempting to identify strategies for the sustainable development of its energy service provision. In this regard, it has been attempted to identify the specific contexts at play within the energy sector of Bangladesh, using this as a basis to formulate policy interventions to address the issue of energy supply and energy sustainability. These strategies for policy reform within the energy sector are then to be trialed through the implementation of specific pilot projects, in order to evaluate their validity.

The primary energy needs of rural Bangladesh can be sustainability met with locally available renewable resources. Small community based energy enterprises, with financial assistance from GOB or local NGO's or international development agencies can be established as community based 'micro power company' which will provide energy for:

(a) household cooking with biogas generated from the anaerobic digestion of dung and agricultural residues and

(b) household lighting electricity produced from low power 'DC' batteries, charged in local PV based battery charging stations run on commercial basis.

However, in its full context, energy cannot be viewed as an isolated entity, but rather in contexts of energy and life-style, energy and the environment, energy and technology, energy and poverty, energy and geopolitics. The issue of energy and development must be placed in a holistic context where energy, and energy sustainability, must be addressed as one component of a broader transition towards economic, social, political and environmental sustainability of a country.

"Inequity is a major source of environmental decline: it fosters over consumption at the top of the income ladder and persistent poverty at the bottom.....People at either end of the spectrum are far more likely than those in the middle to damage the earths ecological health". (Postel, M. 1994)

Notes

[1] World Commission on Environment and Development (the Brundtland Commission), 1992

[2] This ranks Bangladesh as the most densely populated country in the world - excluding city states, such as Singapore.

[3] The World Bank & Bangladesh Centre for Advanced Studies, 'Bangladesh 2020 - A Long-run Perspective Study', University Press Limited, Dhaka, pg. 7, 1998.

[4] Ibid, pg. xx, 1998.

[5] The World Bank, Bangladesh: From Counting the Poor to Making the Poor Count, 1998 (based on 95/96 Household Expenditure Survey)h

[6] Yunus, Muhammad 'Poverty Alleviation: Is Economics Any Help? - Lessons form the Grameen Bank Experience' in Journal of International Affairs, pp 51, Fall 1998, 52, No.1.

[7] The World Bank & Bangladesh Centre for Advanced Studies, pg. 7, 1998.

[8] Rahman, Sanzidur 'Energy Demand Forecast in Bangladesh' in Grassroots, pg 5-16, April-June 1996.

[9] The World Bank, 'Bangladesh - From Stabilisation to Growth', pg 127, 1995

[10] The World Bank, 'Bangladesh - From Stabilization to Growth', pg 127, 1995

[11] The World Bank & Bangladesh Centre for Advanced Studies, pg. xx, 1998.

[12] Bangladesh Centre for Advanced Studies, 'Report on Wind Energy Study Project', Dhaka, 1998.

[13] Goldemberg, Jose 'Leapfrog Energy Technologies' in Energy Policy, Vol. 26, N^{o} 10, pp. 729-741, Aug. 1998.

[14] Although there are potential wind resources within Bangladesh, the wind power values are extremely marginal with a v_{av} of between 3 m/s and 4 m/s. Similarly, although the volumes of water that pass through Bangladesh is enormous, the head (or energy potential) of these flows is very small, restricting viable hydro sites to the Hill Tracts of the South East corner of Bangladesh. Therefore, wind and hydro generation technologies can only be advocated for in limited locations after extensive site research.

[15] Although the efficiency of normal PV cells is considered to be low, at between 10 and 15%, it is the cost per Watt (AUS$10/Watt) that is seen as the major obstacle to the application of PV cells within large power applications.

[16] A lump sum subsidy of Tk5000/- is given to the interested householders in establishing bio-digesters under Biogas Extension Program under BCSIR.

[17] If running an 8W fluoro. light for 4 hrs/day, a 100 A.hr battery should offer 15 to 18 days of operation.

[18] For higher income households the programme should be capable of facilitating the purchase of 'DC' Fans (Tk 5,000/-) and B&W Television sets (Tk 12,000/-), where desired.