Sustainable Energy for Development

A Project Supported by GTZ

Working Paper

Productivity Improvement in Industry through Energy Efficiency Programs

Prepared by:
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PREFACE

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This report has been prepared by the Centre for Energy Studies, BUET for the GTZ project entitled “Sustainable Energy for DEvelopment” (SED).

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The report has been prepared to fulfill the contractual obligation to provide data, information and analysis of the energy sector in Bangladesh with particular reference to energy efficiency. The contents of this report should only be used for the purpose of this appraisal study as indicative results because the consultants did not get enough time to verify all the collected information. In addition many assumptions had to be used for this study.

CONTENTS

1.0 Introduction

An overall view of the primary energy consumption in the year 2004 is shown in Table 1, while Table 2 provides a brief overview of energy infrastructure and resources. About 32% households have electricity connection and approximately 4% households have natural gas supply. The Rural Electrification Board (REB) network covers approximately 40% of rural Bangladesh, but within the grid covered area only 40% households have electricity connection. Renewable energy other than biomass constitutes a very small percentage of the total

energy consumption.

Bangladesh suffers from chronic shortage of electricity and gas. At present, the electricity situation is so bad that at peak hours (5-10 p.m.) approximately 600 MW of load shedding is required. The unreliable electricity has been directly linked to loss of productivity, and hence to lowering of economic growth rate. The World Bank estimates an annual loss of nearly 1 billion dollars due to unreliable power. Even though foreign and domestic Independent Power Producers (IPP) are keen to invest, the Government is wary of excessive private sector participation in the sector, especially for contracts requiring all payments in foreign currency.

Table 1 Primary Energy Consumption in Bangladesh for 2004

	Physical Units	**Energy Units**	**(%)**	**% of Fossil**
Natural Gas	450 bcf	445 million GJ	35.1	69.1
Oil	3.7 million tons	158 million GJ	12.5	24.5
Coal	1.5 million tons	41 million GJ	3.2	6.4
Hydro	1.0 TWh			
Biomass	50 million tons	625 million GJ	49.2	
Solar PV	3 MW (2 GWh)			
Wind	1 MW (2 GWh)			

Table 2 Energy Infrastructure and Resources in Bangladesh

	Total	**Operational**	**Remarks**
Generation	4700 MW	3700 MW	90% gas based
Captive	1100 MW	1000 MW	95% gas based
Refineries	1	1	1.5 million tons/year
Gas Fields	22 Undeveloped – 7	12 Suspended – 3	Reserves – 20 Tcf (5 consumed) Resources – 32 Tcf (mean)
Coal Fields	4 Undeveloped – 3	1 Just starting	Reserves – 204-764 million tons Resources – 2715 million tons
Transmission (Gas)	1856 km	1856 km	90% in the eastern region Severe limitation in most areas
Transmission (Electricity)	3485 km	3485 km	Concentrated in eastern region Severe bottleneck in most areas

2.0 National Energy Policy and Energy Efficiency

The National Energy Policy (NEP) of 1995, which is still valid because the revised one is awaiting approval, was formulated with a view to rapidly increase the consumption of commercial fuels. The energy policy contains a strong

recommendation for increasing commercial energy consumption. The rationale for this is that increased energy consumption will drive economic growth. This line of reasoning pervades the entire policy document. Almost all policy makers in Bangladesh subscribe to the hypothesis that there is causal relationship that flows from energy use to GDP growth. This hypothesis implies that energy efficiency will hurt economic growth. This hypothesis has been severely criticized in recent times, and it has been conclusively shown that energy efficiency is not detrimental to economic growth, and in most cases it can actually assist growth. As may be imagined, in the NEP, energy efficiency is included only as an afterthought.

The updated NEP, which is pending approval, claims to tackle many of the deficiencies of the 1995 policy and some other new issues that have arisen in the last 10 years. The 2004 NEP contains the following issues relevant to this study.

1. 1. Rationalization of energy prices
2. 2. Conservation, energy efficiency and renewable energy

In comparison to the 1995 NEP, the updated one is more positive about conservation, energy efficiency and renewable energy. The government has implemented some conservation measures, but because they are half-hearted attempts, no impact is being observed. On the energy efficiency side, having realized the potential of energy saving light bulbs, the Government took an initiative to replace all incandescent bulbs with energy saving ones in public buildings, but the program is progressing at an extremely slow pace. There exists huge potential in Bangladesh for energy saving bulbs because the largest peak in the daily load curve is the evening peak, which is mostly lighting. Despite the fact that utilities have to resort to load shedding, the potential of energy saving bulbs in tackling the evening peak has not been explored with any seriousness. The utility's efforts have been limited to awareness raising campaigns through newspaper and television advertisements.

1. **3.0 The Energy Scenario of Bangladesh**
2. 3.1 Gas Sector

The gas consumption in the year 2004-05 was 487 bcf, which on a daily basis is 1334 MMcfd (million cubic feet per day). The daily gas consumption now (May 2006) on certain days is exceeding 1500 MMcfd. This indicates that there has been a large increase in gas consumption since last year. Captive power generation and CNG refueling are the two demand areas that are responsible for the large increase.
Therefore, a 10% increase over 2004-05 daily consumption was used for this appraisal study. The percentage daily natural gas consumption is assumed to be 1468 MMcfd. It is worth mentioning that gas consumption has been growing at an average rate of 7% per year for the last 20 years (*GoB Reserve and Demand*

Study, 2003). The breakdown of the 1468 MMcfd of natural gas that is being delivered to consumers in Bangladesh is shown in Fig. 1. As can be seen 63% of the gas is supplied to the two main bulk consumers – the power plants and the urea fertilizer plants.

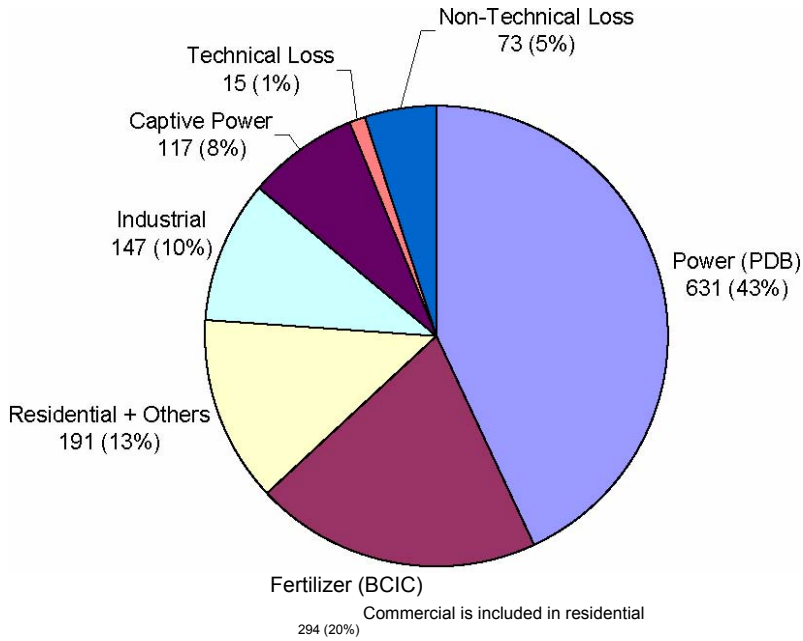

Fig. 1 Natural Gas Consumption in MMcfd (1468)

3.2 Electricity Sector

In the financial year 2003-04, BPDB and the IPPs generated approximately 20,000 GWh (excluding station use) of electricity. This electricity was distributed and sold by four companies. Table 3 shows the consumption of energy and Table 4 shows number of consumers by category. The difference between the net generation (20,000 GWh) and the total shown in Table 3 (15,333 GWh) is the system loss. A noteworthy observation is that the largest electricity seller is the Rural Electrification Board.

Table 3 Energy Consumption (FY 2003 – 04)

Consumer Category	Energy Sold in a Year (GWh)					
	PDB	DESA	REB	DESCO	Total	% of Total
Domestic	2066.65	1378.51	2475.22	677.87	6598	43.03%

Commercial	504.72	222.43	320.159	103.84	1151	7.51%
Irrigation	78.79	0.18	527.46	0.00	606	3.96%
Industrial	2086.44	1529.13	2468.77	597.47	6682	43.58%
Others	204.27	*48.24*	13.56	28.85	295	1.92%
Total	4941	3178	5805	1408	15333	100.00%
% of Total	32.22%	20.73%	37.86%	9.18%	100.00%	

Table 4 Consumer Number (FY 2003 -04)

Name of the Utility	Consumer Category in Numbers						Up to the Month		
	Domestic	Commercial	Irrigation					Industrial	Others
PDB	1,359,724	347,635	14,284	46,164	27,151	5,394,736	June, 04		
REB	4,542,099	606,666	138,869	95,059	12,043	504,927	June, 04		
DESA	425,595	58,890	26	17,912	2,504	241,964	June, 04		
DESCO	216,565	18,281	0	4,240	2,878	7,936,585	June, 04		
Total	6,543,983	1,031,472	153,179	163,375	44,576	14,078,212			
(% of Total)	46.48%	7.33%	1.09%	1.16%	0.32%	100.00%			

Note: Others include mosque, church, school, madrasa, street light, pump etc.

The prevailing dependable electricity generation capacity in the country is between 3500 MW and 3750 MW. Historically, the annual plant capacity factor has been between 62-67%. This means total grid connected generation can vary between 19,000 GWh to 22,000 GWh. *For this appraisal study, gross generation of 20,000 GWh has been used.*

Figure 2 presents the grid electricity consumption in different sectors (20,000 GWh). It should be noted that this includes the electricity generated by IPPs, but not captive generation.

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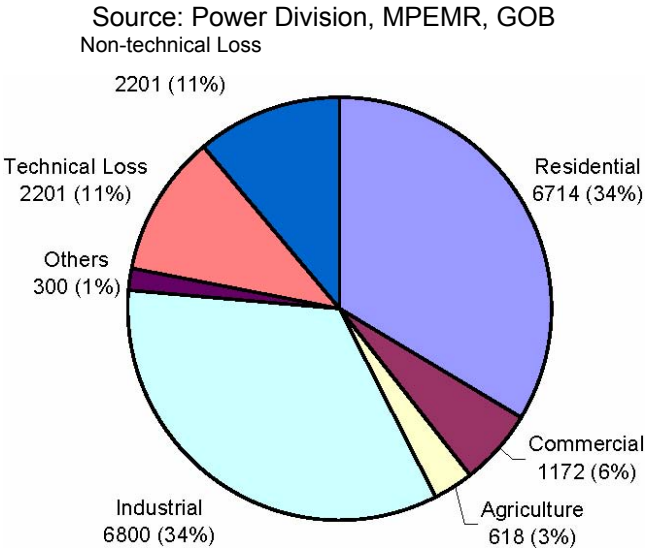


Fig. 2 Electricity Consumed by Different Sectors (20,000 GWh)

1. **4.0 Energy Consumption in Industrial Sector**
2. 4.1 Introduction

Industries in Bangladesh predominantly consume electricity and natural gas. A small amount of diesel is consumed by standby generators in areas where there is no natural gas connection. In most of the western part of the country, which is yet to be connected to the natural gas grid, industries use furnace oil. However, these uses are insignificant, and as soon as natural gas becomes available, these industries will all shift to natural gas. Over 4000 traditional brick kilns scattered all over the country use coal and firewood. Table 5 presents a snapshot view of energy consumption in the industrial sector.

As can be seen from Table 5 the principal source of primary energy in Bangladesh for the Industry sector is Natural Gas. Since nearly 90% of the grid electricity is also generated using natural gas, and most industries use natural gas for captive generation, it is best to analyze the energy consumption only in terms of natural gas.

Table 5 Energy Consumption in Industrial Sector[1]

Fuel	Amount	Typical Use	Remarks
Grid Electricity*	7900 GWh	All Types of Industry	89% Natural gas; 4% Hydro; 7% Diesel and FO
Captive Generation	5200 GWh	Large Industries	95% Natural Gas

Natural Gas*	78 bcf (213 MMcfd)	All	Captive generation, process heat and furnaces/kilns
Diesel		Standby Generators	
Furnace Oil	100,000 tons	Industries in west zone + PDB	6% of grid electricity (PDB)
Coal	1.5 million tons	Brickfields	
Biomass	10 million tons	Brickfields, Road construction, Rice Mills, Sugar Mills, Rural Industries	

**Including non-technical loss*

4.2 Analysis of Industrial Electricity and Gas Consumption

As can be seen from Figure 1, the industrial sector receives 18% of the natural gas, 10% for industrial activities and 8% for captive power generation. The issue of captive generation is discussed further in section 4.3 because of its special importance. The most noteworthy aspect in Fig. 1 is the extremely high system loss. Thus, 88 MMcfd of gas is unaccounted for. Deducting 1% technical loss (i.e. 14.68 MMcfd), 74 MMcfd can be attributed to theft. Since the theft occurs in three sectors – residential, commercial and industrial – the 74 MMcfd need to be apportioned between these sectors. For this appraisal study it is assumed that 50% of the nontechnical loss, i.e., 37 MMcfd of unpaid for gas is consumed in the industrial sector. Most of this gas is used in small boilers and kilns are not in captive generators, because the tariff for industrial use is much higher than captive power (Tk. 5.23/m^3 against Tk. 3.73/m^3).

The electricity produced by 631 MMcfd (43% of the total gas) is consumed by several sectors. As can be seen in Figure 2, 6800 GWh of the electricity is consumed in the industry sector. In addition, a large portion of the non-technical system loss in the form of unpaid electricity bills also need to be added to the electricity consumption of the industry sector. The total electricity consumption from the grid is therefore 7900 GWh in the industry sector. In terms of natural gas this becomes (215 + 35 =) 250 MMcfd.

Table 6 summarizes the gas consumed by the industry sector. It is worthwhile to note that the electricity is expressed in the form of gas in Table 6. As can be seen more than one-third of the total natural gas (as gas and electricity) consumed in the

[1] Estimated in March-April 2006 using available data and expert judgment

country goes to the industry sector. If the large public sector urea fertilizer plants' energy consumption is added then the total consumption reaches nearly 60%. It

is to be noted that the analysis presented for this appraisal study excludes the urea fertilizer industry.

Table 6 Primary Energy (natural gas) Consumed by the Industry Sector

Category	**MMcfd**
Gas Consumed by Industry Sector (boilers, furnaces and kilns)	147
Gas Consumed by Captive Generators	117
Gas Consumed by PDB to Supply Electricity to Industry Sector	215
Unaccounted gas (50% of loss in gas sector)	37
Unaccounted electricity in terms of gas (50% of non-technical loss)	35
Total Gas Devoted to the Industry Sector	550

4.3 Disaggregated Industrial Energy Consumption

While the information in Table 6 is useful, it does not give one any idea in which sub-sector the energy (electricity and gas) is consumed. An attempt has been made to disaggregate the primary energy consumption by industry types. Industrial energy consumption has been disaggregated into the following six categories.

I. Public sector industries other than urea fertilizer plants
II. Large private industries (Having captive generation greater than 2.5 MW)
III. Energy intensive industry groups + Captive Generation (less than 2.5 MW)
 .IV. Significant manufacturing industry groups + Unaccounted large motors and boilers
 .V. Other (industry groups not included in iii and iv)

VI. Small and Medium Enterprises (SME) + Unaccounted medium and small motors and boilers

The analysis of industrial energy consumption is done in terms of primary energy, i.e. natural gas. This means the grid electricity consumed by industries has to be converted to natural gas. This appraisal study has assumed that 631 MMcfd of gas is utilized for a gross generation of 20,000 GWh of electricity. Therefore, for each GWh of electricity 0.0316 MMcfd of gas is required.

A large quantity of electricity consumed by industries is generated using natural gas in the plant premises (captive generation). Within the timeline of this appraisal study, it was not possible to disaggregate this consumption beyond the larger private sector industries that has a generation capacity greater than 2.5 MW. A calculation using 60% capacity factor for 1000 MW of generation capacity reveal that 5200 GWh of electricity is captively generated and consumed. This is nearly two thirds of the 7900 GWh of electricity that is consumed from the grid. Therefore, the total electricity consumed by the industrial sector is approximately 13,000 GWh.

The most noteworthy thing about the energy consumption is the extraordinarily high natural gas requirement for Captive Generation. This is an important aspect of the industrial energy consumption. The unreliable grid electricity implies that nowadays no large electricity consumer (> 1 MW) can expect to run industries purely on grid electricity. Not only is the supply not dependable, but also the power quality (i.e., sag, voltage and frequency) is poor. A total of 28 large industries having a total generation capacity of 144 MW have been identified. Since, the survey has not been exhaustive, it is expected that more such large (> 2.5 MW) industries do exist.

Based on data gathered from generator suppliers, there are approximately 1600 generators having a total capacity of around 1100 MW. There are many more generators in the size range 10 to 200 kW range. However, these are standby generators, and a large portion of those are diesel operated. There are numerous diesel standby generators in the size range 0.5 kW to 10 kW to cope with frequent power outages and extensive load-shedding practiced by the utilities to manage the evening peak. Captive generators consume nearly 40% of the gas supplied to industries. If the present trend in the growth of captive generators continues, then natural gas usage for captive generation will exceed that used in boilers and high temperature furnaces/kilns. Using an average efficiency of 40% and various capacity utilizations as appropriate for a given type of industry, an estimate of the gas consumed by captive generators has been made.

Apart from a few industry types which use natural gas in furnaces/kilns (re-rolling mills, glass, ceramic, tiles and brick) most use natural gas in boilers. A meeting with the Inspector General of Boilers (IGB) revealed that there are approximately 5000 boilers. These are mainly located in Textile Dyeing and export-oriented Garments industries. The approximate sizes and average gas consumptions of these boilers was determined from information provided by Modern Erection (a local boiler manufacturer) and the IGB. Information provided by these stakeholders is provided in Appendix B.

Using expert judgment and approximations, the gas consumptions in the various industries of the five categories listed above have been made. The balance has been adjusted by three categories of captive generators, boilers and motors. The breakdown of electricity and gas consumption into the 6 industrial categories has been performed using available data and expert judgment. *The BUET consultants cannot guarantee the authenticity of this breakdown*. Since this appraisal work is only meant to give indicative results, this breakdown should be considered as illustrative. The Table 7 provides the total natural gas consumption by the Industry sector in Bangladesh based on the assumption described above. In Table 7, Column 2 shows the consumption of grid electricity by the 6 categories of consumers, while Column 2 shows the equivalent natural gas required to produce the electricity.

Table 7 Disaggregated Industrial Energy Consumption

Categories	Grid(millionkWh)	Grid – Eq. Gas (MMcfd)	Captive G. Gas (MMcfd)	Boilers Gas (MMcfd)	TOTAL (MMcfd)
I. Public	*70*	2	5	11	18
II. Large Private	*100*	3	20	10	33
III. Energy Intensive	*1150*	36	103	23	162
IV. Manufacturing	*3700*	116	0	85	200
V. Others	*1430*	45	0	7	52
VI. SME	*1550*	48	0	37	85
Total	*8000*	250	128	173	550

Figure 3 presents the industrial consumption of electricity (expressed as natural gas) and natural gas in the different categories outlined above. These figures have been constructed to provide a good appreciation of industrial energy consumption so that suitable interventions can be designed.

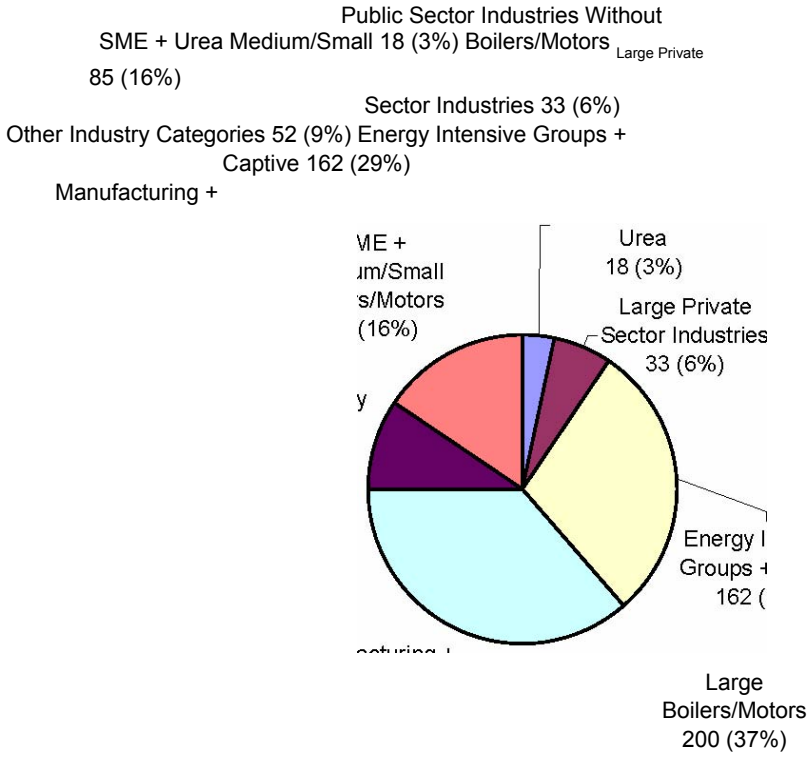


Fig. 3 Energy Consumption in Different Industry Groups in MMcfd (550)

Energy used in Energy Intensive, Manufacturing and Other Industries are shown in Figures 4, 5, and 6 respectively. Clearly, the largest industrial group is the garments industry followed by the textile dyeing industry. In the energy intensive groups, scrap steel processing, pulp and paper, clinker grinding, glass, brick and steel re-rolling mills are important groups.

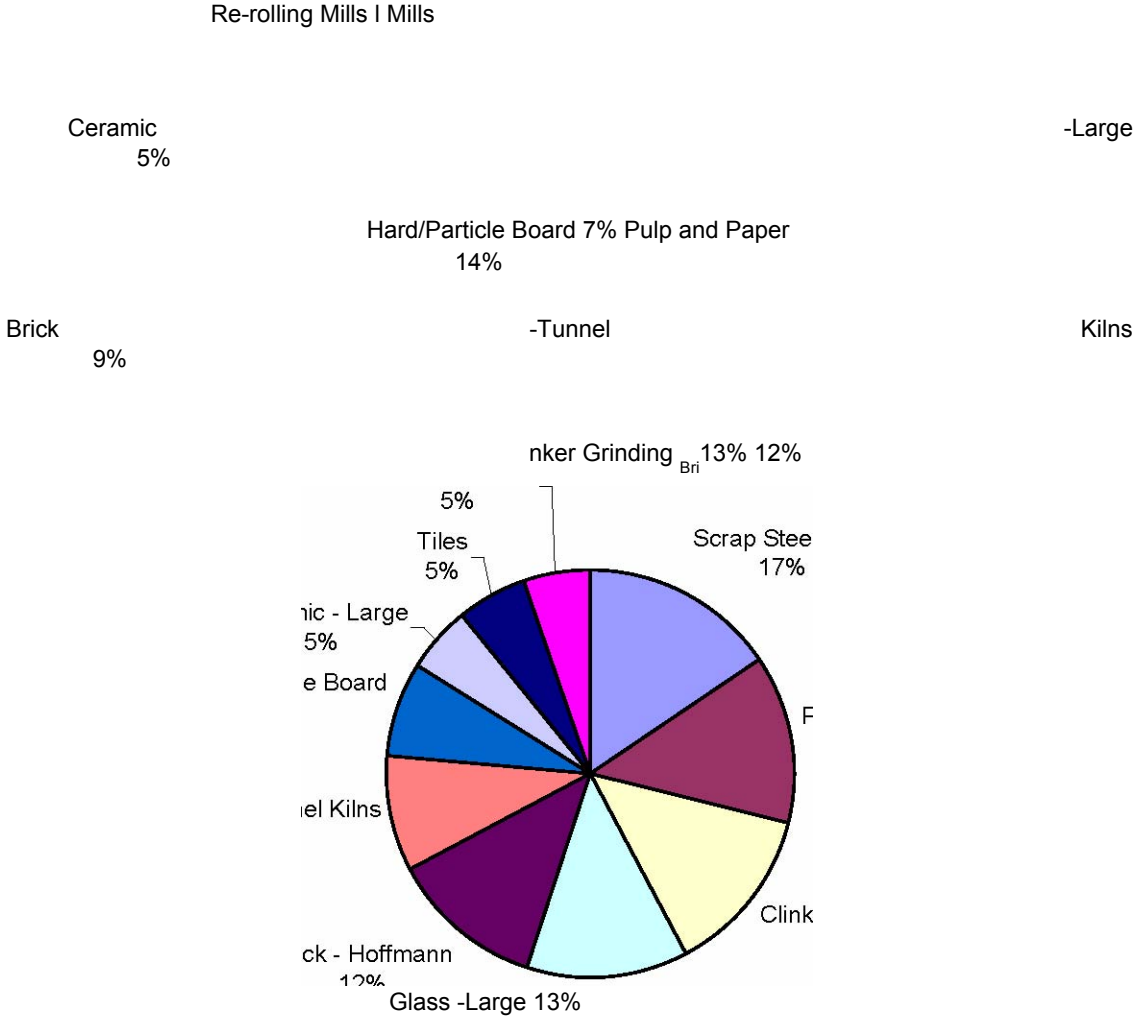


Fig. 4 Share of Different Energy Intensive Industries

Metal Products Textile -Spinning 2%

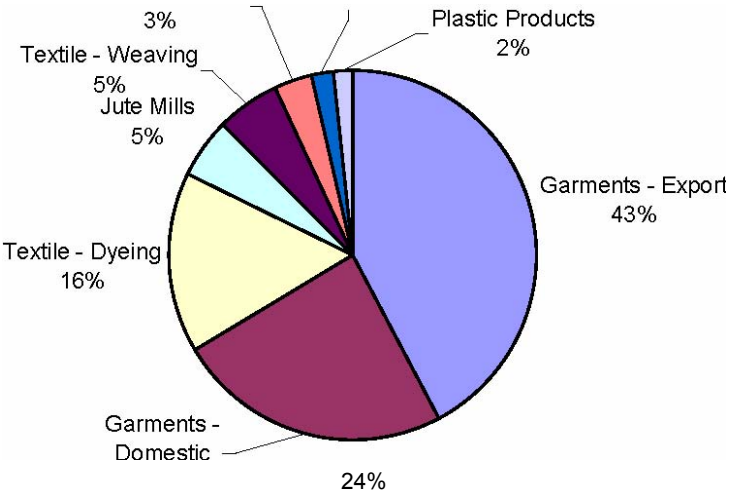
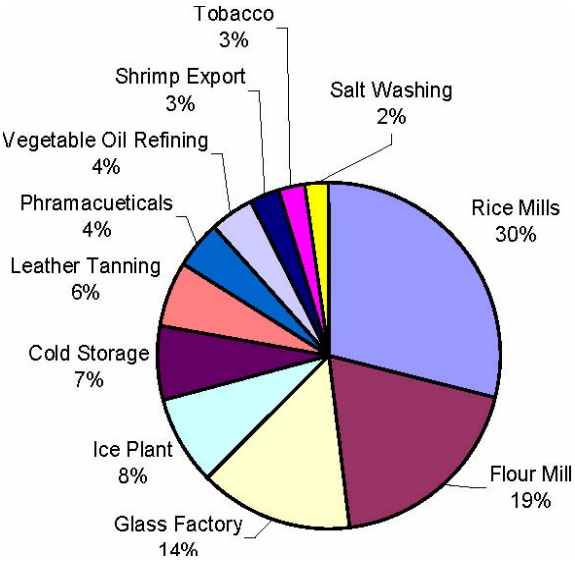


Fig. 5 Important Manufacturing Groups Fig. 6 Important Other Industry Groups



5.0 Problems of the Energy Sector

As shown in Table 1, nearly 70% of the commercial energy comes from natural

gas. The heavy dependence on natural gas is due to the fact that Bangladesh does not have any other energy resource in significant quantities. The coal resources, which were always thought to be small and difficult to develop, is attracting a lot of attention from international coal companies in recent years because of the high energy prices. Despite having significant reserves of natural gas to meet present demand, Bangladesh is failing to develop its gas resources as required to meet increasing demand. Thus, lack of transmission facilities often cause gas shortages in different parts of the country. These shortages are handled by shutting down big loads like power plants and fertilizer plants. However, the problem of gas supply is nothing close to that existing in the electricity sector, and with new pipelines now being built, the problem is expected to disappear in a year or two.

Even though gas will be available in key industrial areas of the country, the increasing trend of captive generation is a worrying issue because the state electricity company is progressively being deprived of creditworthy customers. As remarked earlier this increasing trend in captive generation is due to the extreme problems being experienced by industries with regards to power supply.

The gas sector is also plagued by theft, and it is precisely this problem that has led to the electricity utility becoming a losing concern and unable to fund generation increase. If the gas demand for industries, particularly for captive electricity generation, keeps on increasing, and industries keep on underpaying their gas bills, it won't be long before the gas companies also become losing concerns like the electricity companies. In fact, the gas companies are not investing in exploration and development, and most of the new gas is coming from the International Oil Companies (IOC) with a need to pay them in foreign currency.

The electricity sector of Bangladesh is presently beset with various problems. The immediate problem is that the demand cannot be met. The forecasted electricity growth rate is 10%. The main demand growth is in the industrial sector. There are no plans to add this amount of generation to the grid. BPDB is finding it very difficult to maintain uninterrupted electricity supply as its generating units are mostly old (some are over 35 years old). Moreover, the generating units have become unreliable due lack of spare parts, proper maintenance, etc. As may be imagined, the power quality, which is discussed elsewhere, is low. The power supply system has become so bad that industries have to plan for captive generation. About 1100 MW, which is one-third of grid (BPDB and IPPs) capacity, is captive generation. These captive generators run on gas and are putting tremendous pressure on the gas grid especially in some industrial clusters.

As we look back the concept of electricity supply has changed significantly. Previously the GoB policy was to get foreign soft loans or grants to build power plants and supply the generated electricity to consumers as a not-for-profit

service. The Government even provided some subsidy to the power sector. This has lead to virtual collapse of this vital sector. The present prescription of international donors is to raise the price of electricity to make it a commodity, so that the profits can be reinvested to make the power sector self-reliant. The Government is finding it difficult to do implement this because of public resistance.

Energy prices (gas and electricity) have been traditionally low in Bangladesh and theft is endemic. Therefore, there is very little incentive to be energy efficient from an energy cost point of view. Most energy efficiency improvement has come about as a result of other things, such as autonomous efficiency improvement, product quality improvement, environmental regulations, etc. A brief discussion on some issues relevant to energy efficiency in Bangladesh is provided in Appendix A.

1. **6.0 Brief Description of Significant Industries**
2. 6.1 Scrap Steel and Re-rolling Mills

A description of scrap steel and re-rolling mills is provided in Appendix B. For the re-rolling part of the factory, drawing of ingot to make rods of different sizes is done using a fixed speed motor and load change is performed using mechanical gears. Instead of this arrangement, an adjustable speed drive could be used. In that case the size of the motor could be reduced, thus saving on energy cost.

For the steel making section, which is the induction furnace portion, the entire process is very crude. Much heat is lost from the furnace. The entire process could be improved as is bring done in the modern mills being set up nowadays. This would lead to significant reduction of heat loss, hence electricity.

6.2 Cement Clinker Grinding Mills

There are more then 15 cement clinker grinding factories in the country. These use big motors (in MW size) for crushing clinkers and are large consumers of electricity. These motors are often not the best quality available internationally. Because of unreliable power, these industries have started to opt for captive generation. The energy intensive nature of these industries makes these good candidates for energy efficiency improvement. The drive system could be studied for efficiency improvement.

6.3 Pulp and Paper Mills

Fifteen years back the pulp and paper industry was totally in the public sector with 4 very large mills. The scarcity of wood coupled with intense competition from imported paper forced one newsprint mill to shut down and another white paper mill to be disinvested. Apart from imports, the gap is being filled by small scale (compared to the public sector plants) private sector pulp and paper mills.

Probably the fastest growing industrial sub-sector now is pulp and paper. The demand for paper is growing fast because of the Government's plan to rapidly increase literacy rate. Today, paper making is a profitable business because of the high price of paper.

There are more than 15 small-scale paper mills. The raw material for these mills is mainly imported waste paper. Because paper making machines are extremely expensive, many of these mills are using imported second-hand machines. Due to the age of these machines, the energy consumption is high. The newer machines have many heat saving features. The pulping section, which does not require sophisticated equipment, is either fabricated locally or imported at very low cost from manufacturers that sell inferior technologies. There exists good opportunities for energy efficiency improvement.

6.4 Ice Plants and Cold Storage

There exists a huge demand for ice in Bangladesh because refrigeration and freezing facilities are not readily available for transporting and storing perishables such as fish. The ability to store fish for long hours has given fishermen the power to demand a better price than previously. The demand for ice is therefore very robust with cities growing at a very fast rate. These industries operate fairly large chillers. While some of these chillers have acceptable efficiency, most are old and inefficient.

Cold storages, which are used to store potatoes for approximately 6 months of the year, are an important energy intensive category. These are very similar to ice plants, except for the fact that they do space cooling rather than ice making. The temperature maintained is between 4 and 8 ^{o}C. The technology employed is vapor-compression refrigeration running on electricity purchased from the national grid. An average cold storage has a capacity of 100 tons of refrigeration (TOR). There are more than 50 such storages around the country. In one study performed by BUET, it was found that there exists a good opportunity to use captive generation coupled with absorption refrigeration to lower the energy requirement. Since very clean natural gas is available in parts of the country, an excellent opportunity exists for employing cogeneration technology. In the cogeneration schemes considered, electricity will be used to operate part of the existing vapor compression chillers, and the waste heat from the gas turbine generators will be used to operate absorption refrigeration chillers.

6.5 Glass and Ceramic Factories

Glass and ceramic manufacturing are well known energy intensive industries. As may be imagined because of the large population, there is a significant demand for glasses and ceramic products. The general population being very poor is always looking for very cheap products. These cheap products, as may be imagined, are invariably manufactured using extremely crude technologies, and in a very energy inefficient manner. The low energy costs and energy theft helps in sustaining these crude and energy inefficient technologies.

6.6 Hoffmann Kilns

Even though the natural gas fired Hoffmann Kiln technology has been around for some time, no effort has been taken to improve its efficiency. There are about 30 Hoffmann kilns located in Dhaka, Chittagong and Comilla. A Hoffmann kiln is rectangular in shape and measures 300-400 ft by 60 ft. Its operation is very similar to the traditional brick burning kiln. The predominant difference between the Hoffmann Kiln and the three types of coal fired kilns commonly used in Bangladesh is the fixed roof, which enables bricks to be fired throughout the year. The inner portion of the roof of the kiln is arched and has a firebrick lining. The thick wall with good insulation prevents heat loss to the surrounding, but the high thermal mass is a problem if kilns have to shut down, and that often happens in Bangladesh. These kilns use natural gas as their fuel, and are environmentally fairly benign compared to other three types of coal burning kilns. The burners for these kilns are pipes with holes drilled in them. The combustion air is drawn in from the section that was previously fired using an induced draft fan. There is no provision for primary air.

6.7 Textile Dyeing

After Garments, this is the single largest industrial category. Estimates vary as to how many of these factories exist. Two reliable sources have put the figure at 700. These textile dyeing and finishing industries cater to both small and large yarn and garment manufacturers. While some are large units, most are very small operations. The energy consumption is mainly for boilers. A typical plant has a boiler in the range 1-3 tons/h. The owners of these units are small-time operators, and definitely cannot afford to invest in new or good technologies. As it happens, these industries are highly polluting. The effluents from these industries are causing serious pollution in water bodies in several industrial locations around the country. For these industries it is best to address the problem in an integrated manner, i.e., through an environmental management system (EMS), cleaner production or eco-efficiency. There is at least one on-going program on pollution reduction of textile dyeing industry. However, the problem is simply too big to be addressed by such a small effort, and other programs are bound to be initiated. Thus, there exists good opportunity to complement those future programs.

6.8 Small and Medium Enterprises (SME)

There are more than 25,000 SMEs in Bangladesh. Their average electricity demand is approximately 5 kW. Since the number of industries is large, crosscutting technologies such as motor retrofit, boiler efficiency improvement, housekeeping + energy management and possibly cogeneration are most likely to yield good results. According to a local consulting house called Waste Concern, in one industry that produces metal boxes for UPS, a 65% reduction in energy consumption was achieved through the development of an environment management system (EMS).

7.0 Crosscutting Energy Efficiency Improvements

About 32 percent population has access to electricity. Lighting constitutes 70 percent of the evening peak of electrical load. The evening peak of electricity demand constitutes mainly lighting load in garment industries and residential sectors. Households use incandescent lamps while garment industries use fluorescent lamps extensively. Garment export constitutes more than 50% percent of the total export of the country. There are about 4100 garment industries registered with the Bangladesh Garment Manufacturers and Exporters Association (BGMEA). These industries on average consume about 1 million kWh of energy per day. The energy efficiency potential in these industries should be studied in detail. Energy efficiency can be achieved in these industries by introducing energy efficient devices (electronic starter) and efficient fluorescent lamps. Compact fluorescent lights (CFL) may be useful in households, shops and for some specific lighting needs. The market share of CFL is 100,000 pieces per month. The penetration rate is about 2 percent. A few years back, low quality CFLs had flooded the market. However, bad experiences of users with these CFLs, and campaign by reputed CFL manufacturers have successfully reversed this trend. Nowadays, good quality CFLs are assembled locally. There are no qualified lighting engineers in the country. Only one course on Illumination engineering is taught to architecture students of BUET. There is a dearth of engineers having formal training in illumination engineering in the country.

Electric motor drive consumes over 70% of electricity in many industrial plants. About 1.2 percent (by number) industrial consumers consume 44 percent electric energy (Table 3) and this energy is almost equal to domestic consumption, although domestic consumers comprise of 47 percent (by number) of total consumers (Table 4). Improvement of power quality, motor and transmission efficiency and monitoring and maintenance could increase the efficiency of energy use. Low voltage, sag, flickers and other such problems are common phenomena. Cheap, low quality motors (Table C2) are often used in many small and medium scale industries. Voltage balancing of all the three phases is not always practiced. Many small and medium scale industries cannot employ qualified graduate electrical engineers to look after their electrical system.

Distribution transformers are mostly manufactured in the country. Except for some reputed local manufacturers, the quality of transformers is not very good. More information on transformers are provided in Appendix B: Stakeholder Perspective.

Gas is predominantly used in boilers, furnaces and kilns. There exists good opportunity to improve the efficiency of gas use in these applications. The state of gas boilers in the country is well summarized by the comments of two of the stakeholders that the BUET Appraisal team visited. The comments are presented in Appendix B: Stakeholder Perspective.

In recent years, local fabricators are making many boilers, kilns and furnaces.

Previously, over 90% of the gas consuming equipment and devices were imported from reputable manufacturers from developed countries (Japan, Germany, UK and USA). Nowadays these are imported mostly from China and India. Even Korean products are now being considered to be expensive. Small and Medium Enterprises (SME) use mainly locally fabricated devices. In one estimate there are more than 25,000 SMEs. Even though most of these are predominantly electricity consumers, gas, coal and oil are also used. Needless to say, efficiencies of these devices are extremely low, and in most cases these devices are also unsafe.

8.0 Suggestions for Energy Efficiency Improvement Projects

No real effort to promote energy efficiency has ever been taken in Bangladesh. Following the Gulf War crisis, an effort was taken to promote energy efficiency. This led to the creation of the Energy Audit Cell. However, with the decline of world oil prices, all momentum was lost. In recent years, high energy prices and a global awareness about greenhouses gas emission has again brought energy efficiency in the focus. In both the 1995 and 2005 National Energy Policy, energy efficiency is mentioned, but until a year back no initiative had been taken. The soon to be formed SEDA should be suitably empowered to deal with this important issue.

Even though at present Bangladesh is in an early stage of industrialization, the industrial base will be fairly large in 15 to 20 years time because growth rate of this sector is fairly high. This implies that a lot of industrial infrastructure will be built in the next two decades. Moreover, in the same period many very old industrial plants and equipment/machinery will be retired, and due to autonomous efficiency improvement many very inefficient industrial processes will be phased out. Therefore, it may be more effective to target those industries that will be built in the next two decades rather than to improve on the existing ones. In fact, it may be a total waste of resources in some cases because those specific industries would have gotten phased out in the natural course of events. Moreover, very inefficient industries can easily be forced to change using regulatory measures.

More than 90% of the equipment and machinery used in Bangladeshi industries are imported. Therefore, monitoring of the imported energy-consuming devices may prevent inefficient ones from being imported. Awareness raising of importers, suppliers, vendors and industrialists may yield very favorable results.

It is the aspiration of every country that 100% of all equipment and machinery should be fabricated in the country. In developing countries like Bangladesh sometimes, these are manufactured at less than one-fifth of the imported cost. This provides huge incentives for industrialists. But invariably the locally fabricated products are unsafe, more polluting and most importantly energy

inefficient. On the other hand, as remarked earlier only a small proportion of industrial equipment and machinery used in large industrial establishments are fabricated in Bangladesh. To provide incentives for the good fabricators and drive out the bad ones, the following two suggestions are given.

I. Those that are making inferior products should be shut down, or given assistance to improve
II. Provide technical and other assistance to improve equipment and machinery fabrication in Bangladesh

It should be appreciated that decision to implement energy efficiency measures would be taken by the top management. Thus, however much training is imparted to lower staff, nothing much will happen until top management is convinced. Engineering economy analysis of the proposed retrofit must be prepared and explained to the top management. For this, awareness raising of top management must be accompanied by hand-on training of personnel who are responsible for such functions in the industry.

Consulting services from private sector service providers in energy efficiency is one of the key elements of a successful energy efficiency project. Good reliable consultants who can provide the total service are required to carry forward the work developed by EE experts. These consultants/service providers need to be supported for two to three years. In some cases all that may be required is a bit of hand holding, but in others new companies may need to be created and fostered.

Many parallel efforts are ongoing that directly or indirectly deal with energy efficiency. This project can benefit vastly if resources are pooled from one or more of such programs with this one. This will also avoid duplication and resource wastage. Some of these efforts relating to the industrial sector are.

I. Promotion of ISO 14001
II. Cleaner Production
III. Eco-efficiency
 .IV. Promotion of Energy Management System (EMS)
 .V. Sustainable Energy programs

VI. CDM and VERS

The biggest impediment to energy efficiency is low energy prices for the industrial and commercial sectors. In addition, many import or other policies that affect the industrial sector are antithetical to energy efficiency improvement. Some of these have been described in Appendix A. A thorough study of different policies that may affect energy efficiency should be undertaken. Dialogue should be initiated with the relevant ministry in conjunction with the finance ministry about changing policies that discourage energy efficiency and to bring in new

legislation to promote energy efficiency.

A study should be initiated to find out the industrialists' point of view regarding energy efficiency; in particular the answer to why they do not implement energy efficiency measures should be sought. Even though many of the reasons are known and well documented, there is a good chance that hitherto unknown reasons may emerge. Most importantly, they may suggest more appropriate and readily implementable solutions.

Appendices

A. Some Bangladesh Energy Sector Issues

B. Stakeholder Perspective

C. Some Relevant Data

C1. Daily Load Curve of the BPDB Grid
C2. Electric Motor Data

Appendix A

Some Bangladesh Energy Sector Issues

Energy Intensity of the Economy

Bangladesh's per capita commercial energy consumption is one of the lowest in the world, and is only one-third that of its neighbors, India and Pakistan. There is a constant pressure on the Government to increase the commercial energy supply. A comparison between India and Bangladesh with respect to per capita energy consumption and energy intensity of the economy is presented in Table A1. The redeeming feature of the low energy consumption with respect to its GDP is that Bangladesh's energy intensity of the economy is very low. India's per capita income is only 1.3 times that of Bangladesh despite all the high growth rate that India has been experiencing for over a decade, whereas India's energy intensity is 2.3 times that of Bangladesh. There are several reasons for this. The two most important ones are (i) India's self-reliant policy has forced the construction of many highly energy intensive industries like steel and aluminum making, which were in the initial stages internationally non-competitive, and (ii) India being a large economy has managed to develop many indigenous technologies, which invariably are highly energy inefficient compared to the state-of-the-art or advanced technologies. In contrast, Bangladesh did not pursue a self-reliant policy, and is obviously disadvantaged in the game of developing one's own technologies due to its small economy. Thus, Bangladesh is fortunate

in not having very many inefficient energy intensive industries and in using imported technologies from Japan and Korea. Therefore, if the present trend can be continued, Bangladesh should be able to develop and achieve poverty alleviation at a very low per capita CO_2 emission.

Bangladesh may be doing well in terms of energy intensity, but in terms of hydro and renewable electricity, Bangladesh is lagging behind India as can be seen from Table A1.

Table A1 Energy Data Comparison between Bangladesh and India Parameters in 2003-04	**Unit**	**Bangladesh**	**India**
Per capita GDP	US$	440	564
Per capita GDP (PPP)	US$	2000	3100
Energy Intensity of GDP	kgoe/US$	0.29	0.65
Energy Intensity of GDP	Bangladesh = 1	1	2.25
Per capita Commercial Primary Energy	kgoe	115	340
Per capita Electricity	kWh	185	460
Biomass % of Total	%	49.2	20.7
Per Capita Hydro	kWh	6.3	69
Per capita Renewables (Wind, Solar PV, etc.)	Bangladesh = 1	1	35

Source: Various, but mostly from www.nationmaster.com

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This comparison may not be completely fair because India has large renewable energy potential, but when one considers the fact that only a small percentage of India's potential has been harnessed, Bangladesh performance in renewable energy is very poor.

Import Policy for Energy Consuming Devices

Bangladesh's import policy is heavily biased against energy efficient devices. The 1995 NEP has made the following suggestion for encouraging efficient use of energy
– "Incentives for fuel efficiency for all categories of end-uses may be given". Not a single law has been formulated to promote it. Since most of Bangladesh's energy consuming devices are imported, the import duties are the most important items affecting the cost of equipment and machineries. Goods are considered to be luxury items purely on the basis of their price. There is no provision for judging the durability or energy efficiency of an imported item. This approach does work when one is evaluating a Mercedes or BMW, which are indeed luxury items

compared to say a Toyota or Nissan, but it totally fails in the case of a hybrid, which is much more expensive than a similar sized standard automobile. The most classic example of such policy aberration was evident in the case of Compact Fluorescent Lamps (CFL). These were at one time classified as luxury items, and a 60% tax was imposed, whereas the highly energy inefficient incandescent bulb enjoyed a 15% tax. Many other examples can be cited.

The transport sector, which consumes the bulk of the imported oil, is severely constrained by restricting rules and regulations that do not encourage efficiency. Exorbitant taxes and duties on transport vehicles and their accessories forces transport owners to continue using old vehicles for as long as they can. In fact, using periodic engine rebuilding, a truck or a bus can be made to operate indefinitely. The high taxes also encourage entry into the country of second hand engines, and sometimes from other developing countries where pollution laws are strict. These factors cause the specific energy consumption of vehicles to be extremely high in Bangladesh. In addition, these vehicles are responsible for a considerable amount of local pollution in all cities. Lax enforcement of environmental laws means that polluting vehicles can operate with impunity. The overall costs of running old buses even after very high operation and maintenance expenses are significantly lower than those for new vehicles. The other issue that discourages owners from upgrading their fleet is the regulated bus fare. The per kilometer bus fare set by the Government is so low that bus operations are marginally profitable.

Energy Prices

Energy pricing in Bangladesh is in the doldrums. Ad-hoc policy making has dominated the fixing of prices. Except for coal, the Government fixes all energy prices in Bangladesh. In most cases it is concentrated on recovering immediate costs. Not only do prices not allow for funds accumulation for expansion and development, but also sometimes even the depreciation costs are not fully recovered. Needless to say, resource cost is not accounted for. This type of energy pricing is not uncommon in developing countries. The main thrust of such pricing is to provide energy at affordable prices. This approach in most cases is unsustainable because the utility very quickly becomes a big burden for the government. This is precisely the situation prevailing in Bangladesh, and the utilities are in no position to finance their expansion causing energy shortage.

The legacy of energy prices that do not reflect the true cost can be traced back to the historical development of the energy sector. Most of the pre-1990 infrastructure has been built through grants and no/low interest loans from bilateral and multilateral agencies. Therefore, there was very little pressure on utilities to operate efficiently. The ready availability of cheaply extracted natural gas made matters even worse. Since the early nineties, these easy sources of funds have been drying up, and most developing countries are being forced to buy electricity from IPPs. The requirement to pay IPPs in convertible foreign

currency is now forcing Bangladesh to rationalize its energy prices.

In recent years, energy prices have been somewhat rationalized, and in many cases, they do reflect all costs and even includes a profit component for expansion and development, but a substantial chunk of the potential revenue gets eaten up by what is euphemistically called “system loss”. At least half of the system loss is nothing but theft. System loss is probably the biggest evil plaguing the energy sector. The electricity sector suffers from a 23% system loss, and amazingly the gas sector also has a 6.5% system loss. It is to be noted that 63% of the gas is supplied to two public sector entities (power plants and fertilizer factories), where there are no losses. All the gas distribution system loss is concentrated in the 30% that is supplied to the residential, commercial and industrial users. Therefore, the system loss is 18% in these three sectors. These system losses imply loss of revenue, and both the electricity and gas utilities are unable to fund any of their development programs.

Even though the oil sector is better managed, and prices are somewhat rationalized, the situation is far from perfect. The Government still manages to supply diesel at prices slightly below cost by using a cross subsidy. Thus, gasoline, which is perceived to be a rich person’s fuel, is heavily taxed. The principal reason why the management of this sector has been much better than the gas and power sectors is that 100% of the oil has to be imported using scarce foreign exchange. One significant problem, however, has been the incidence of smuggling of petroleum products into India because prices there have been consistently higher. Decades of improper pricing have conditioned the public to expect low prices. Thus, in recent years when oil price has escalated, the Government is finding it extremely difficult to increase prices due to public resistance. India has successfully managed to deregulate prices such that the pump prices are able to reflect changing international oil prices on a weekly basis.

Conclusions

Like in most developing countries, there exist plenty of policy confusions that are counter to good planning for keeping energy consumption low while promoting growth. The following problems have been identified.

I. Energy policies that encourage wastage and discourage efficiency improvement
II. Import policies that do not discriminate between efficient and non-efficient devices
III. Funds shortage that cause inferior technologies to be used
IV. Governance problems that allow wastage and theft of energy products to thrive

Addressing these identified problems is the key to a more energy efficient

development path. Even though it may appear that some of these issues can be easily addressed, in reality it isn't so. For example, the import policy in Bangladesh is designed to bring in revenue for the Government, and energy insecurity is a direct function of the poverty status of the country.

However, the single most important factor that directly or indirectly influences all others is the issue of funds shortage. Since the early nineties, Bangladesh has been opting for inferior technologies in almost all sectors. Needless to say, these low cost technologies are highly energy inefficient. Bangladesh certainly does not have the luxury to take decisions on the basis of life-cycle costing. Tackling these difficult issues would require generous, sustained and long-term support from developed countries because developing countries are in no position to overcome these overnight and on their own.

AppendixB

Stakeholder Perspective

Chief Inspector of Boilers
Ministry of Industries
Motijheel

BUET consultants along with some other members of GTZ appraisal team met with the Chief Inspector of Boilers (CIB) at his office at Motijheel. The CIB was very frank and open and offered all possible help to the team. BUET consultants had extensive discussion with him about the number and status of boilers in Bangladesh.

The CIB revealed that there are approximately 5000 boilers registered with his office. These boilers are predominantly in the size range 1 to 5 t/h. There are thousands of boilers used for parboiling of rice. These boilers are very small and not covered by law. These are made indigenously using local technology, and are very inefficient (10 to 20%). Inspectors inspect all boilers once a year, but their concern is safety and not efficiency. Inspectors have certain parameters from which they can predict how the boiler is functioning. The most important one is the stack temperature. However, they have no equipment to determine excess air.

The CIB made the following observations with respect to efficiency.

I. Even though all boilers pass the test from a safety point of view, the firing practices are extremely poor in many boilers, but because it does not fall under their jurisdiction, they cannot do much about it.

II. Since they do not posses all the equipment to determine efficiency, they are not certain how a boiler is performing, but from stack temperature they can make some preliminary assessment
III. Based on preliminary assessment, the CIB believes many boilers are operating in the 70% efficiency region
IV. The boilers that are in the most neglected condition are in the Textile Dyeing Sector. Also, many of the Garments sector boilers are not in a good shape
V. The most prospective size range for intervention in boiler efficiency improvement is the 1-5 t/h. More than 50% of the boilers are in this size range

Since inspectors are all engineers, and all boilers are inspected once a year, the

office of the CIB is very well suited for determining the efficiency of boilers. The inspectors can very easily be trained in boiler efficiency determination. The office of the CIB is undergoing expansion, and therefore, they can very easily devote space for a laboratory for boiler efficiency determination.

Engr. Jawharul Gani
Modern Erection
Tejgaon, Dhaka

Modern Erection is the most well-known boiler manufacturer in Bangladesh. They also provide various other services to industry including fabrication of vessels, water treatment plants and effluent treatment plants. Thus, they possess extensive and in-depth knowledge about industrial boiler operation in Bangladesh.

The boilers made by Modern Erection and other Bangladeshi boiler manufacturers are all below 1 t/h capacity. Thus, all boilers of capacity greater than 1 t/h are imported. The Chief Inspector of Boilers informed us that at the present time Bangladeshi boiler manufacturer do not have the requisite fabrication facilities.

Mr. Jawharul Gani identified five major issues with boilers. These are:

I. Most boilers in the country are not tuned properly, and as a result are operating inefficiently.
II. Many of the older oil fired boilers have been converted to gas fired ones using extremely crude burners. Some of these burners are not even burners, but merely metal pipes with holes in them.
III. There is a propensity to import old boilers from developed countries. Many of the imported boilers were oil fired, which were converted to gas fired ones as described above. Even though these boilers are from developed countries, these require proper re-installation when they arrive in the country, but that is rarely done.
 .IV. There is very little knowledge and understanding about boiler efficiency.
 .V. The small boilers (< 1 t/h) are being manufactured in the country by small

time fabricators who have absolutely no understanding of either safety or efficiency. These operators basically copy models of other more reputed manufacturers.

VI. Proper burners are expensive items, and there is a strong tendency to cut costs by using inferior products

In view of the above, Mr. Gani believes there is a significant potential of improving boiler efficiency in Bangladesh. However, he cautioned that only a very good strategy could achieve the objective of efficiency improvement. He mentioned that despite demonstrating to industrialists the savings due to boiler efficiency improvement, they are reluctant to make the initial efficiency improvement and/or pay consultants like themselves for their services. Most industries do not possess the necessary instrumentation to audit a boiler. Therefore, industries are not aware of the loss that they are incurring. He believes that people are either not motivated enough (often due to lack of understanding), or are reluctant to make investments with their own money.

Engr. Nurul Akter
Director, Energypac Electronics Limited
Tejgaon

The appraisal team met Mr. Nurul Akter, Director, Energypac Electronics Ltd., a leading manufacturer of compact fluorescent lamps (CFL). To date they have been assembling CFLs. Initially they were importing components from Sri Lanka, but now they import from China. The quality of their CFL is good. They soon will go for production of LED lamps; both DC and AC. Fluorescent Lamps (FL) are extensively used in Garment factories. These lights usually use magnetic ballast, which is very inefficient. Mr. Nurul Akter believes that these ballasts can be replaced by good quality efficient electronic ballast. He also has a novel idea of modifying existing magnetic ballast circuit to improve its efficiency, i.e. reducing consumption of these ballast. The conventional 4 feet, 40 watt FLs could be replaced by efficient 4 feet slim FLs.

Mr. Akter thinks that for energy efficiency in lighting, the Government should ensure that only good quality CFL and other bulbs are produced and imported. There should be strict laws and legislation to ensure the quality of lighting products and accessories. He pointed out that today in the market all quality of lighting products are available. Inefficient, low quality, cheap lights and motors have much higher sales than high quality, reasonable price electrical products. Mr. Akter believes that unless these anomalies are removed, energy efficiency measures will be very difficult to implement.

Engr. Md. Abdur Razzaque
Executive
Transformer Division, Energypac Engineering Limited
Motijheel

Nowadays nearly all power transformers for industries are manufactured in the country. As transformers are heavy and bulky items, industries normally do not like to import transformers. The 33/11 KV transformers vary in size from 1 to 7.5 MVA. These transformers are supplied to various industries such as cement, paper, plastic, ceramic, leather, textile, garments, steel re-rolling, metal fabrication, toiletries, chemicals, agro and food industries. There are about ten reputed and many more no name brand transformer companies in the country. One of these companies is dedicated to single-phase distribution transformer manufacturing specially designed to cater to the needs of the Rural Electrification Board (REB). BUET consultants met with an executive of the largest transformer manufacturer (Energypac Engineering Ltd.). According to him their transformers meet the international standard. They can make those more efficient but it may not be cost effective especially in the Bangladesh context. He pointed out the huge increases in the price of copper and steel. Since transformers are made mainly from these two materials, it is very difficult to lower prices. Energypac also manufacture 10/12 MVA, 132/11 KV transformers.

From the discussion with the Energypac executive it appears that it is very difficult to achieve energy efficiency in a cost effective manner in the transformer side especially using new efficient ones. However, if transformers that are very old or those made by non-brand manufacturers are replaced by those of reputed manufacturers, a savings of a few percentage point can be achieved.

CEO
Kadamtali Steel and Re-rolling Mill
Narayanganj

BUET Appraisal Team visited a steel and re-rolling mill at Shyampur, near Narayanganj. The mill produces about 1500 tons of MS construction rods. It uses scrap iron collected locally and imported. For making ingots the mill uses two induction heating furnaces of 5 ton capacity each. Previously arc furnaces were used in Bangladesh, but because these were not cost effective, these slowly got phased out. When asked whether the mill was using a good technology, the CEO remarked that they were not. However, many new mills were being set up that are using very good and efficient technologies. The principal reason why many mills are opting for good technology is that the demand for 60-grade construction rod, which cannot be manufactured using the old technology, is going up.

In re-rolling mills, ingots measuring 8’x6”x4” are heated in a gas-fired furnace and then drawn successively through presses of different sizes to make MS rods of 16, 18, 20, 25, 30-mm sizes. A 415 V, 600 KW induction motor performs the steel pressing. The motor and the induction furnace are made in India.

The mill is run in two shifts for 15 hours daily, and avoids the evening peak hours. The mill has a 6 MVA, 11/415 KV transformer and uses about 4.1 MW load and pays a bill of about Taka 5 million per month. As the mill runs in two

shifts with a 6 hour gap, both the induction and re-rolling furnaces have to shut down and start again. This periodic cooling and heating results in huge loss of energy and is very costly for the mill. Moreover, any power interruption for more than 30 minutes can cost the mill huge losses as the molten iron gets cold and need to be re-heated.

Senior Vice President
Islami Bank Bangladesh Limited
Motijheel, Dhaka

BUET consultants met with a banker who has over 20 years experience in the Banking sector. The person concerned has more than one bank experience. The following are his observations regarding energy efficiency.

I. For financing new projects banks only look at the economic viability of an industrial project. They are not concerned about energy efficiency
II. They will only invest in an energy efficiency project if they initially funded the particular industry and the project initiator can prove that it will make savings and repay the loan. They may do this even if the industry is not presently profitable, but the project developers must demonstrate that the energy efficiency component will improve its financial viability
III. It is highly unlikely that they will get involved in an industry just for an energy efficiency component
IV. By and large, banks in Bangladesh are not interested in funding energy efficiency projects especially because these are difficult to monitor and in many cases profitability is marginal
V. Leasing companies are more likely to be interested in investing in refurbishing and energy efficient technology for existing industries
VI. However, there is a lack of awareness among the banking community about energy efficiency projects

The above discussion makes it amply clear that to fund energy efficiency projects through commercial banks the following three actions would be required.

I. An awareness raising campaign for general staff, and more in-depth capacity development for project evaluators
II. For some time availability of concessionary funds must be ensured
III. Some legislative pressure from the Government must exist

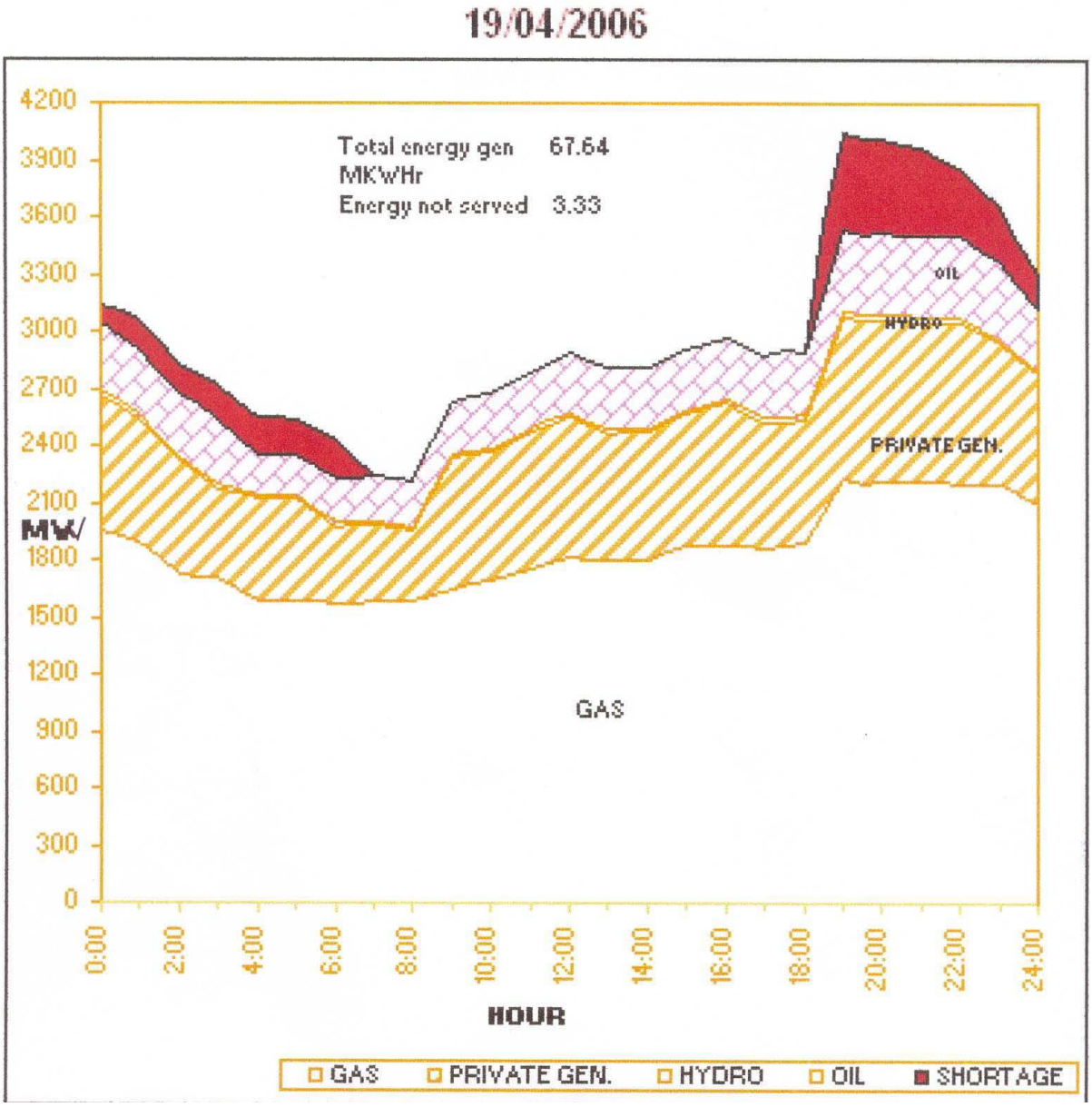

Fig. C1 Daily Load Curve of BPDB Grid

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C2 Electrical Motor Data Table C2 Indicative Price of Motor-pump Sets for Water

Lifting

HP	Model/Brand	Made	Price	Remarks
1	Atlas	USA	Tk. 8,500	
1	Pkm 60, Pedrollo	Italy	Tk. 8,400	
1	1LA7, SIEMENS	India	Tk. 6,127	
1	Pedro	China	Tk. 2,800	
1	Diamond	China	Tk. 2,600	
1	Gazi	China	Tk. 3,500	Local brand
1.5	Pkm100, Pedrollo	Italy	Tk.12,800	
1.5	A n B	China	Tk. 6,500	Local brand
1.5	Panda Gold	China	Tk. 5,000	
2.0	Pkm200, Pedrollo	Italy	Tk.15,500	
2.0	1LA7, SIEMENS	India	Tk. 8,452	
10.0	6SR 27/7, Pedrollo	Italy	Tk.96,000	
10.0	A n B	China	Tk.30,000	Local brand