BRUGGER UND PARTNER AG

KEPZ- feasibility study

on renewable energies and

energy efficiency in Bangladesh

Final report

Project management „KEPZ-feasibility study":

BHP – Brugger and Partner Ltd. (Dr. Michel Geelhaar)

Project partners „KEPZ-feasibility study":

- Youngone Ltd.
- Rahimafrooz Renewable energy Ltd.
- Entec Ltd.
- Holinger Ltd.
- ETH Zurich

This study was supported by:

REPIC - Interdepartmental Platform for Renewable Energy and Energy Efficiency Promotion in International Cooperation. Contract No. 2010.01

Bangladesh / Switzerland, April 2011

Acknowledgments

Special thanks to the Chairman and CEO of Youngone Group, Mr. Kihak Sung. Many thanks to the responsible people from Youngone Bangladesh, namely Mr. Yameen and his fantastic engineering team, and from Korean Export Processing Zone (KEPZ), namely Mr. Shahjahan, General Manager, and his team. Many thanks to the Swiss Government and the various Swiss Governmental Agencies represented by REPIC, which funded this study.

Special thanks to the project partners, proving that energy experts from almost all over the world can easily cooperate by having the same targets and motivations. Explicitly I want to name:

- All partners from RREL, namely Mr. Sohel, Mr. Utpal and Mr. Shayan
- All partners from Entec AG, namely Dr. Jorde
- All partners from Holinger AG, namely Mr. Deiss and Mr. Jeitz
- All partners from ETH Zurich, namely Mr. Schmid and Mr. Peters

My thanks also go to Bangladesh and their fantastic people, trying hard every day to surmount the difficulties of this poor, but dynamic country. You showed me every day, that the daily struggle is worthwhile going step by step towards a sustainable future.

With best compliments

Dr. Michel Geelhaar

Berne, April 30th 2011

Glossary

KEPZ	Korean Export Processing Zone
EPZ	Export Processing Zone
DEPZ	Dhaka Export Processing Zone
CEPZ	Chittagong Export Processing Zone
BPDB	Bangladesh Power Development Board
CDM	Clean Development Mechanism
CER	Certified Emission Reductions
REDD	Reducing Emissions from Deforestation and forest Degradation
USD	United States Dollar
MW	Megawatt
MWh	Megawatt hour
KW	Kilowatt
KWh	Kilowatt hour
KWp	Kilowatt peak
Kg	Kilogram
t	Ton
LNG	Liquefied Natural Gas
HFO	Heavy Fuel Oil
PP	Power Plant
PDB	Power Development Board
BPC	Bangladesh Petroleum Corporation
ERL	Eastern Refinery Limited
IPP	Independent Power Producer

Units used in this study

Generally SI-units (International System of Units) are used in this study:

Energy related units:

- MW_e for electrical power installed (e.g. "the generating set has a capacity of 3 MW_e")
- MW_{th} for thermal power installed (e.g. "the boiler's thermal capacity is 5 MW_{th})
- MWh_e for electrical energy produced in one year or day installed (e.g. "the generating set produces 12'000 MWh_e /year")
- MWh_{th} for thermal power installed (e.g. "one boiler generates 50 MWh_{th}/day")
- The fuel consumption should be given in tons (diesel, coal) or m^3_N (Gas) **and** MWh of energy content.
- The amount of **full load hours** (flh) assumed should always be given.

For explanation:

An electric generating set of 3 MW_e that produces 12'000 MWh_e /year runs 4'000 full load hours.

Area etc.:

- Length, area and volume should be given in metric units. m, km, m^2, ha, km^2, m^3

Temperature:

- Temperature should be given in degrees Centigrade (°C).
- Steam pressure should be given in bar.
- Amount of steam flow should be given in tones per our (t/h) **and** in MWh_{th} (see above).

Gas volumes/flows:

Gas flows are expressed differently in different industries. The expression Nm^3/h stands for "Normal" m^3/h which means the volumetric flow refers to "normal" atmospheric pressure (1013 mbar) and "normal" temperature of 20ºC.

Currency

100 Bangladeshi Taka (BDT) equals 0.94 Euro or 0.71 USD

Table of Contents

Annexure 87

List of Figures

List of Tables

Executive Summary

Natural gas is the major source of power generation in Bangladesh and therefore also in the Chittagong region. Due to present acute gas crisis in the country it is highly unlikely that ever growing energy and power demand and supply gap will be mitigated in the prevailing condition. In assessing the total energy demand for the entire zone, the industry mixes considered are small to medium high energy intensive. The energy demand (both Power and Gas) is of course highly depending on the industrial mix; the demand analysis shows a 193 odd MW as total demand of KEPZ with a estimated annual gas demand for the selected industries of around 102 Million m^3 per year (only 16 MW are received so far from BPDB, which is roughly around 8% of the total power requirements).

To run the zone as quickly as possible KEPZ will have to consider and access commercially available and competitive fuel sources to pass this transition stage. As HFO has been allowed by the government to use for private power generation, KEPZ may seriously consider the HFO option – which is compared to diesel power less costly - in their next phase of development until the country is going to have significant availability of coal and natural gas. In this case, it is also important to account CO_2 emissions from coal based power generation, as it might make the usage of coal much more expensive in terms of emissions and also affect the impression of developing a green economic zone burning less pollutant fuels.

In light of the above KEPZ seriously has to consider to explore as many renewable and energy efficiency potential as possible. But the various studies proved that **the potential of renewable energies is low** due to many constraints:

- There is **hardly any potential from hydro power generation** (no identified potential for run-of-river hydropower, power from the ponds and the Karnafuli river; the tidal power technology did not come out as promising; power generation from waste water is not a significant contribution; thermal ground water use is not considered feasible as well), except absorption chillers taking the warm ground water, but initial investment would be higher than the conventional one.

- There is a **limited potential from biomass power generation** (the annual biomass-flow is estimated around 18'742 tons with 12.4% dry-matter resulting usable organic dry matter, around 1'819 tons per year. If annually 40,000 tons of municipal waste is collected from Chittagong municipality and added with KEPZ biomass residues, the potential CHP capacity would be 1’035 kWel. and 1’129 kWth[1])

- Although the opportunities in the field of **solar thermal energy use at KEPZ are rather limited** there is still some potential to generate ***hot water for dorm facilities*** (the assessed options do not yield attractive financial returns. This is primarily due to two reasons. First, fossil fuel prices, in particular gas, are heavily subsidized in Bangladesh. Second, the solar resource in the Chittagong area is generally attractive, yet, between May and September in particular direct normal irradiation required for concentrating solar thermal plants drops significantly).

- Considering the nationwide energy crisis, **solar can be opted as one of the viable alternatives**. Although solar installation cost is way higher than diesel it has no fuel requirement as in the case of diesel and can be managed with little maintenance (for KEPZ the most attractive and feasible solar solution is to provide lighting loads to all infrastructural, logistical and domestic infrastructures).

It is more promising to keep the production sites as energy efficient as possible: all the identified **potentials to reduce energy consumption for manufacturing shoes are well proven in terms of technology** and can be implemented with limited investment. Based on the analysis of a Youngone shoe production site at CEPZ around 30 % of the energy might by saved through better efficiency – the main conclusions of energy efficiency measures are[2]:

- Simple measures, such as better insulation, economizers, repairing leaks, etc.

- Consequent usage of Co-generation

- Taking energy efficiency measures into account during the planning phase of sites or facilities. This includes intelligent placement of generators and boilers, short pipe lines, etc.

As KEPZ wants to position itself as a “green industrial zone” some complementary investments can make it more lucrative to the global stakeholders. Additionally KEPZ as a whole has a pretty high potential of earning carbon revenue from its green initiatives under Clean Development Mechanism (CDM): the exploitation of renewable energy technologies

[1] Things should be in mind that it is often complicated to ensure the supply of municipal waste from external sources and a no of issues involved rather than technical and commercial feasibility only.

[2] A new study, partially supported by REPIC, is going to try to deepen the energy efficiency outcomes. The study is part of a bachelor thesis, which will be conducted by R. Wicky and M. Wild from ZHAW; it will be published by End of September 2011.

(RET) has a great potential for climate protection. Financial investment in CDM associated with adequate national policies could greatly advance RET towards the stage of commercialization[3]. Combined savings of about 40 MWh on total electricity consumption and 60 MWh on thermal energy consumption through energy efficiency, process improvement, adoption of RET and energy efficient building design can be achieved. And if this is converted to CDM projects for a period of 10 years, total accumulated Certified Emission Reductions (CERs) from these two sectors will be approximately:

- From Power = 914’500 CER
- From Heat application = 1’371’810 CER
- **Total** = 2’286’360 CER @ 12 USD for Revenue
  = **27.5 Million USD**[4]

To explore all potentials of renewables and energy efficiency the concept of **hybrid grid** could be a good option in KEPZ: with a significant share of renewables, KEPZ might have a smart hybrid grid in operation which not only serves the purpose of diversifying the energy mix but enables KEPZ to implement a CDM project and earn revenues and global reputation as well.

To endorse a **sustainable industrialization** in an industrial / commercial zone, the energy-mix might include an essential part of renewable energies (as a “working thesis”). To reach this goal it is important to go step by step. The first part could be the illumination of the factories which can be achieved by solar energy. Adequate incentives might guarantee the use of renewable energies from the very first planning of the zone. A concept of “hybrid grid” will help to integrate renewable energy sources with the existing conventional sources. Adjacent to solar, biomass and hydro the hybrid grid might also include wind energy, a still undiscovered potential especially in the coastal areas of Bangladesh. Finally the high potential of energy efficiency measures (around 30% energy-savings possible) must be explored – today and tomorrow, always!

[3] In this respect Bangladesh is in a good position as Government has already developed the “Renewable Energy Policy of Bangladesh” in 2008.

[4] This calculation is a first rough estimate by Rahimafrooz (Bangladesh) and should show the possibilities of CDM. However, for a project more specific the number of CER’s should be evaluated again.

1. Introduction

Bangladesh is a developing country having an enormous human resource potential. The Government of Bangladesh is fully determined to encourage foreign investment for the country’s economic development. With this in mind the government of Bangladesh awarded a big parcel of land to one of the major foreign investors, Youngone, to develop it as the first private economic zone, the Korean Export Processing Zone (KEPZ). The country’s economy will have a significant growth once this zone is fully developed.

1.1 Project set-up

KEPZ feasibility study aims to find out the “best” energy solutions for a sustainable eco friendly industrial zone. The study includes the feasibility of exploring potentials of using renewables as well as alternative fuels for conventional power generation. It also aims to identify the energy efficiency scopes in “KEPZ shoe production”

KEPZ is one of the first private Export Processing Zones (EPZ) in Bangladesh. It is expected to bring up to 250’000 jobs in the zone and additionally 100’000 zone-related service jobs in the next seven to ten years. KEPZ[5] intends to position itself as a “green industrial zone”; therefore it wants to contribute to a sustainable energy portfolio and efficient industrial production. The “KEPZ-feasibility study” therefore aimed to identify potentials of renewable energies, focusing on technical and economic viable “best practice” energy solutions. The study includes the feasibility of biomass, solar thermal, solar photovoltaic and hydropower usage, as well as identifying the energy efficiency measures to optimize the energy and material flows within the planned “KEPZ shoe production”.

1.2 Objectives of the study

The main objectives in order to accomplish this are listed below:

1) Analysis of the current and future energy constraints of Bangladesh emphasizing on the region of Chittagong and its overall impact on the socio-economic development of the region.
2) Feasibility of “Best practice” energy solutions in the field of renewables such as biomass, solar energy and hydropower at KEPZ[6].
3) Assessment on the existing energy usage pattern of CEPZ shoe factory and identification of potential energy improvement

5 For more details see Chapter 2.3.
6 The analysis of wind-potential was not part of this feasibility study.

measures in terms of energy efficiency in the newly constructed KEPZ shoe factory.

4) Exploration of the potential of developing a “hybrid-grid” at KEPZ (expressed in carbon credits).

Based on the empirical findings of KEPZ the study also aims to extrapolate the renewable- and efficiency-potentials to other industrial facilities in Bangladesh, especially to the government owned EPZs (DEPZ and CEPZ).

1.3 Methodology of the study

The study has been completed by acquiring both qualitative and quantitative information by primary and secondary data collection methods. The brief points on methodology are as follows:

Primary data collection and assessment:

Primary data has been acquired in several ways as follows:

- Field surveys (under specific guideline)
- Information based on industries and equipments
- Key informant interviews(KII)
- Group discussion / workshops[7]

Secondary data collection and assessment:

Secondary data has been collected from public and government sources, other publications and from KEPZ sources on the following issues:

- Current and future energy scenario of Bangladesh and Chittagong
- Geographic and climatic condition of KEPZ and Chittagong region
- Conventional fuel alternatives for KEPZ power generation
- Potential of renewable energies in KEPZ
- CEPZ and KEPZ shoe factories
- Other relevant information/data

[7] All involved partners met in April 2011 at KEPZ and explored together the renewable- and efficiency potentials directly in the field.

1.4 Achievements

The study lasted from February 2010 to April 2011. Not all goals have been fully achieved: due to the methodological difficulties while analysing energy efficiency measures the study got delayed by 2 months. Then the overall development of KEPZ was delayed by another year; the shoe production sites are under construction now, but the energy production and distribution has not yet been decided up to know. Because of this it was neither possible to develop a (quantitative) energy concept for KEPZ, nor to calculate potential investments etc. The following table lists topics to be covered in this study and the respective level of achievement.

Table 1: Achievements

Field	Comments	Achievements
Baseline / "Energy concept" (by RREL)	Overview of the current, midterm and long term energy situation in Chittagong and its implication on KEPZ / "KEPZ shoe production": Viable overall energy production and distribution concept for KEPZ (based on non-renewable energies such as gas, coal, furnace-oil and/or diesel as reference model for further calculation) including estimation of total investment and maintenance cost, availability of primary fuel within project life span. Assessment of the specific energy production and distribution concept for shoe factories at KEPZ and scope of application of energy efficiency measures at KEPZ shoe production	Achieved Not achieved (reason: the development of KEPZ is still ongoing – first step will be the implementation of the planned shoe production complex by Youngone, which also took more time) Partially accomplished (a new study will define concrete energy efficiency-measures)
"Hydro" (by entec)	In the field of "hydropower" the following aspects will be covered: - Small hydropower potential within the KEPZ zone - Small hydropower potential outside KEPZ, but nearby - Potential of the Karnafulli River (tidal or hydrokinetic) - Thermal hydro potential	Achieved
"Biomass" (by Holinger Ltd.) **"Solar" (by RREL)**	Determination of the biomass availability within KEPZ as residue of agrarian or food products processing respectively as organic residue of other processing (direct combustion, etc.) Additionally it will be determined whether there are possibilities to get biomass from off-site sources, such as biomass waste from the nearby city of Chittagong or, for example of Jatropha and/or other energy plants). Determination of the "solar"-potential at KEPZ / "KEPZ shoe production" based on "best practice" which includes solar energy solutions for lighting, cooling, heating machines / equipments.	Achieved Achieved

"Solarthermal" (by ETH)		Achieved
"Cleaner production" (by Holinger / RREL)	The proposed shoe production plants at KEPZ will be examined regarding compliance with the Cleaner Production standards. The energy demand under these standards / scenarios for housing / infrastructure and for shoe production will be analysed and adequate measures will be proposed to be taken in order to reach the respective standards / scenarios.	Partially accomplished (reason: construction of the shoe production sites has not yet been finished)
"Hybrid-grid" (by entec)	Based on different scenarios, some options for developing, operating and controlling KEPZ "hybrid-grid", including energy storage, demand management, load balancing etc. will be developed	Partially achieved
"Ecological impact" (by RREL)	Exploration of the overall ecological impact of the "KEPZ hybrid grid" resulting in earning of carbon credits in KEPZ.	Achieved

A new study, partially supported by REPIC, is going to try to deepen the energy efficiency outcomes. The study is part of a bachelor thesis, which will be conducted by R. Wicky and M. Wild from ZHAW; it will be published by End of September 2011.

2. Socio-economic aspects of KEPZ

2.1 Bangladesh

Bangladesh is gradually in the track of development with number of obstacles still to overcome

Bangladesh is a small country in the eastern part of the South Asian subcontinent. The country is bordered by India in the east, west and north, and by the Bay of Bengal and a small border strip with Myanmar on the south. It has a land area of about 147,570 Km^2.

Figure 1: Map of Bangladesh

The economy of Bangladesh has grown 5-6% per year since 1996, despite political instability, poor infrastructure, corruption, insufficient power supplies and slow implementation of economic reforms. In these years, Bangladesh's gross domestic product (GDP) has been growing at an average rate of 5.5%. In 2008 Bangladesh's GDP growth rate was 6.19%. The main contribution came from the service (54.5%), industry (26.3%), and the agriculture sector (19.2%). Of these three sectors, the industry sector showed the highest growth, which was 8.5%.

2.2 Chittagong

Chittagong is the major port and prominent commercial city of Bangladesh with more than 10 million inhabitants. It is the second largest metropolitan city of the country. Chittagong is standing as a major port city and is involved in the significant industrial development of the country. Most of the industries in this region are situated near the Bay of Bengal and alongside of Karnafuli river. Chittagong is a home of a large number of light to heavy industries. Around 40% of the heavy industrial activities of the country are located in Chittagong city and its adjacent areas, including dry docks, dock yards, oil refinery, steel mills, power plants, cement clinker factories, pharmaceutical plants, chemical plants, cable industry, textile mills, jute mills, urea fertilizer factories, ship breaking yards, food processing units etc.

It is worthwhile to note that in 2007 & 2008, Chittagong experienced a remarkable increase in the GDP growth, comparing to the growth rate of the whole country. The main reason behind this increasing growth is the development of industries and exports in Chittagong. Chittagong contributed a GDP of about $21 billion BDT in 2008 with a significant annual growth rate of 16.29%. It is estimated that in 2020 the GDP of Chittagong will be about $39 billion BDT.

2.3 Korean Export Processing Zone (KEPZ)

KEPZ is located at the southern part of Chittagong and situated at the estuary of the river Karnafuli and the Bay of Bengal.

The zone was handed over by GoB in 1986 and was issued "license to operate" in 2007 in favour of KEPZ authority.

Figure 1: KEPZ Master plan

The zone was basically a hilly terrain of 10 square kilometres when handed over by the government to the Youngone group in 1986. Aiming to be a green industrial zone, the barren land is developed by constructing 17 artificial water bodies purposed to store rainwater, planting of more than 1.3 million trees to address soil erosion, preparing specific agricultural zones and so on. After completion of basic infrastructural development including 10 km of roads, basic accommodation etc., the "license to operate" was given to KEPZ in 2007.

The area of KEPZ can be categorized into a Processing and a Non-processing Zone as attached in Annex-A. The processing zone includes individual industry plots and the non-processing zone includes all the other facilities (green belt, housing area, etc.) The industry plot takes up around 51.8% of the whole KEPZ area.

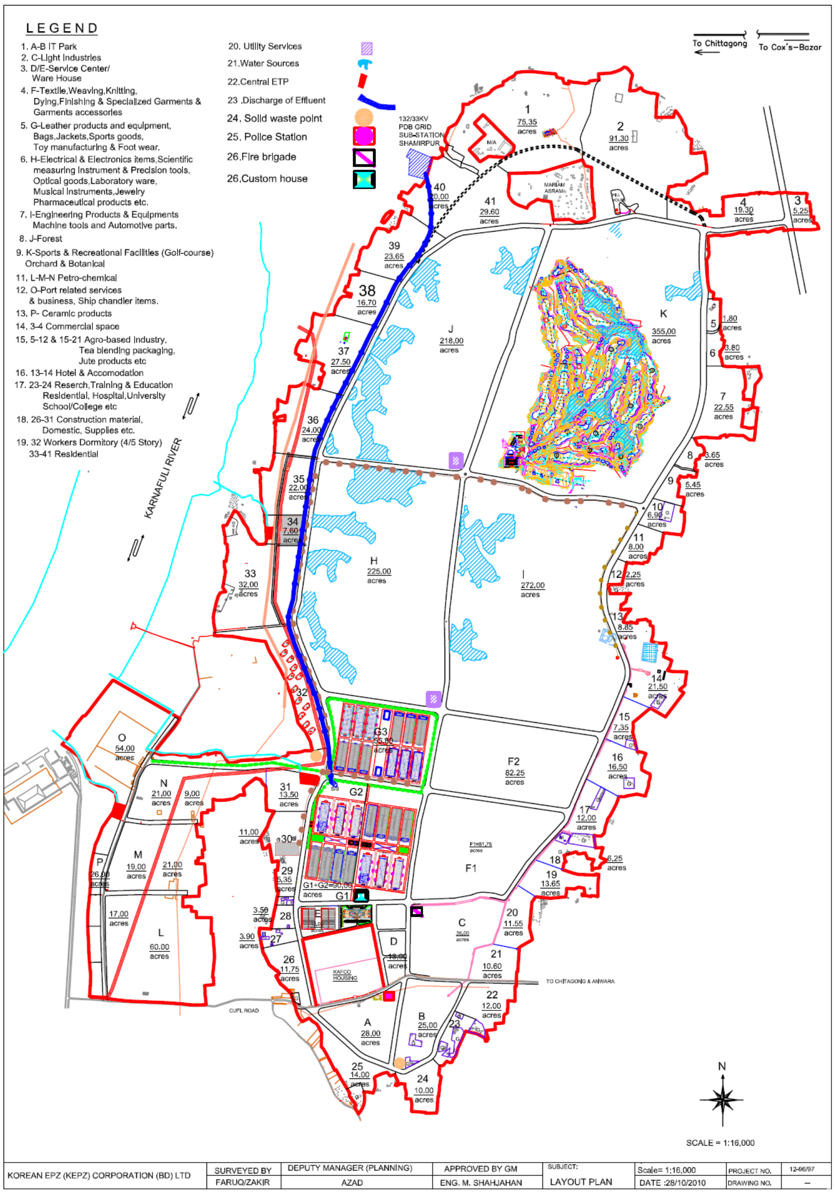

Figure 3: KEPZ situation plan

3. Energy scenario

3.1 Power Sector-Policy Framework

The power sector structure of Bangladesh comprises of integrated utilities like Bangladesh Power Development Board (BPDB) having business interests in generation and distribution at retail end and distribution companies like DESA, DESCO, WZDPC and the 70 operational Palli Bidyut Samiti (PBSs) under the aegis of the Rural Electrification Board (REB). The following figure describes the industry framework of the existing power sector.

Power Sector of Bangladesh is experiencing a major reform with the introduction of different policies and heading towards multiple energy buyer models to encourage private sector participation.

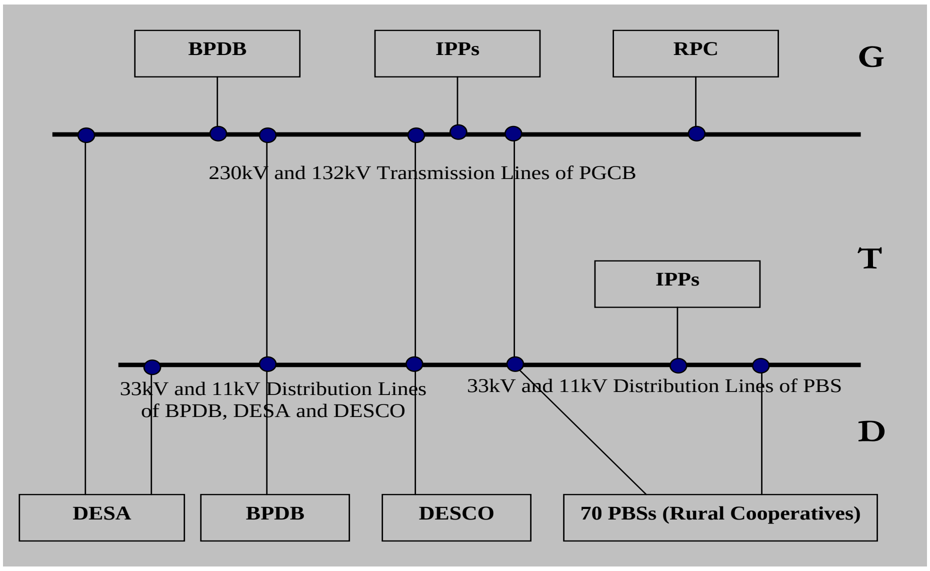

Figure 4: Institutional Framework of Existing Power Industry

The generation part of the electricity chain comprises of the generating assets of BPDB, Independent Power Producers (IPPs) and Rural Power Company Limited (RPCL). Bangladesh currently has a Single Buyer Model with BPDB for buying power from the generation companies in the private sector[8]. However, exceptions exist as for example the direct sale of electricity to PBS via embedded generators of the Summit Power Company as per Small Independent Power Plant (SPP) policy.

The government of Bangladesh has undertaken significant reform measures in recent years in an attempt to address the chronic problems of low levels of electricity access and the deficit in

[8] For more details see Fig. 17 in chapter 9.1 "Considerations of a Merchant Power Plant".

generation capacity in the power sector. The development of these policies intends to encourage private sector participation, which is one aspect of the reform measures. Moreover the government is trying to shift away from the single buyer model to multiple buyer models to bring competition into the electricity industry. In this regard, a recent policy (Policy Guidelines for Enhancement of Private Participation in the Power Sector, 2008) has been approved, where open access to the national grid for private producers for selling power is allowed. In addition to this the government wants merchant power generation in the form of IPPs to eradicate the severe power crisis.

In October 1996 a policy statement, “Private Sector Power Generation Policy of Bangladesh” was published, which provides a number of incentives to encourage private investment in generating facilities. This policy sets out the way in which private sector participation is obtained through the implementation of IPPs. Subsequent amendments were made to the Policy in 2004. The policy provides the tariff structure for IPPs to sell electricity, fiscal incentives and other benefits including exemption from corporate income tax for 15 years and exemption from customs duty and VAT on imported equipment. The Captive Power Policy 2004 attempts to bridge the demand-supply gap in the Bangladesh power sector especially at peak times and provides an avenue for captive power producers to sell surplus power to utilities. Renewable Energy Policy dated October 2009, allows the private sector to establish renewable energy projects and to sell electricity to utilities or final customers under unregulated tariffs.

3.2 Countrywide energy scenario at a glance

Bangladesh is suffering from an acute energy crisis. Natural Gas is the main source of commercial energy (altogether heat and electricity) in Bangladesh as shown in the figure below.

Total installed generation capacity: 5,500 $MW_{e.}$

Maximum generation: 4,900 $MW_{e,}$

Average generation: 3,600 $MW_{e.}$

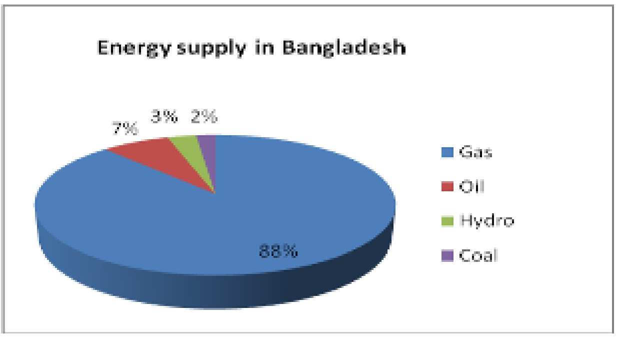

Figure 5: Total aggregated commercial Energy Sources of Bangladesh

The Bangladesh Power Development Board (BPDB) along with its four subsidiary companies is responsible for the generation and the distribution of electrical power in most areas of Bangladesh; whereas Rural Electrification Board (REB) distributes power to the rural areas.

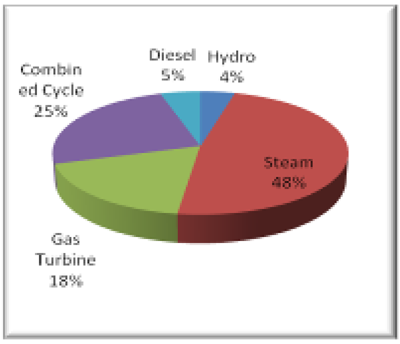

Figure 6: Power generation mix of Bangladesh

As depicted in the figure shown here, hydro, steam, gas turbines, combined cycle and diesel generation are the main means utilized to generate electrical power in the country by various Power Stations. The high voltage transmission network throughout Bangladesh or the National Grid incorporates 104 substations and the grid substations capacity is 13731 MW_e.

The power sector is under severe crisis due to the ever-increasing demand-supply gaps. Currently, Bangladesh has a total installed power generation capacity of about 5,500 MW_e (including about 1,200 MW_e by IPPs). Aging power generation equipment, rapid depletion of natural gas (affecting the NG based generators), the country's economic growth and poor demand forecasting are restricting the current maximum generation to about 4,900 MW_e with an average routine generation of about 3,600 MW_e. Data recorded on 27th March 2010 shows that the total nationwide power demand was 4282 MW_e while the total power generation was 3825 MW_e. This accounted for a total nationwide gap of 457 $MW_{e.}$ The gap is normally bridged trough programmed forced load shedding.

According to the BPDB System Planning Directorate, within the next 5 years 6336 MW_e of electricity will be added to the grid by new power plants from both public (3275 MW_e) and private (3061 MW_e) sectors. However, due to the shortage of gas supply most of the plants are still in the phase of initiation.

As gas remains the main source of power generation, it is highly unlikely that Chittagong will meet the demand-supply gap, if the current gas crisis persists.

Based on the national Power System Master Plan (PSMP) adopted in 2005, there is a forecast that by 2015, the peak power demand will reach to 9786 MW_e.[9]

3.3 Power and gas scenario of Chittagong

Current Power Situation in Chittagong:

The Chittagong region is allocated to receive 11.5% of the total power generated nationwide, distributed by the national grid. In addition, Chittagong also has a number of public, private and rental power plants that are listed in Table 1. These plants have a total generation capacity of 859 MW_e. The Malancha Power Plant exclusively generates electricity for the Chittagong Export Processing Zone (CEPZ). During low demand hours of CEPZ, the surplus generation is contributed to the Chittagong grid. However, primarily due to gas shortage, the current generation of these plants is alarmingly low.[10].

Table 2: Power generation plants in the Chittagong region

Power plant	Fuel Type	Generation Capacity (MW_e)
Kaptai	Hydro	230
Raujan 1 & 2	Gas	420
Shikalbaha	Gas	88
Energis Power	HFO	55
Regent	Gas	22
Malancha Holdings	Gas	44

[9] In some instances industries which are already established with the uncertainty of power, already shifted to own generation from either Diesel or HFO.

[10] At the moment nobody knows the future of Bangladesh in terms of gas. Government so far has taken the initiative for third round bidding for allocating off-shore gas block to the international IOCs like Cairn Energy, Shell etc.

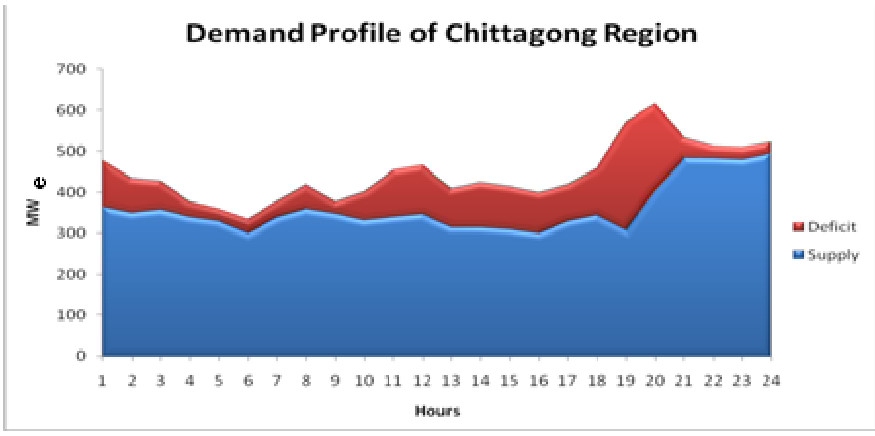

Figure 7: Hourly supply and deficit curve for Chittagong

Recorded on the 15th of March 2010 (Source: tg. PDB)

The curve in the above figure can be used to get a brief idea about the current power situation in Chittagong. It can be seen that at 1900 (peak demand hour) there was a deficit of 210 MW_e. Data provided by Chittagong PDB revealed that through March 1 and 15, the average power generation per day (at peak hour) in the Chittagong region was 334.35 MW_e and the average load shedding was 241.5 MW_e. As summer approaches, this situation is expected to worsen.

Table 3: Planned Power Plants as per BPDB System Planning Directorate

New Power Plant	Generation Capacity (MW_e)	Type of fuel	Status
Sikalbaha Gas Turbine	150	Gas	Tender under evaluation by GOB
Kaptai Power Plant Extension (6th & 7th unit)	100	Hydro	waiting for funding
Sikalbaha Combined Cycle Power Plant	225	Gas	Funding from Kuwait expected.

***Source**: BPDB*

Chittagong PDB forecasts a 10% rise in power demand every year in the Chittagong region. Based on this forecast, the expected demand in the region will be 992 MW_e in 2015. BPDB System Planning Directorate has plans to add 475 MW_e in the Chittagong region by

2015 (Table 2) of which 375 MW_e are expected from the new gas based plants. It is highly unlikely that Chittagong will be able to generate 375 MW_e (full capacity) from gas sources if the current gas crisis persists.

Current Gas Situation in Chittagong:

Present gas demand in Bangladesh is about 2.71 Mio Nm^3/h[11], whereas the maximum production capacity is about 2.30 Mio Nm^3/h. Due to constraints of gas transmission system the actual production is around 2.12 Mio Nm^3/h from 17 gas fields. At the present trend of consumption growth, the demand for gas is expected to rise to 5.38 Mio Nm^3/h by 2020.

Gas is supplied to Chittagong by Gas Transmission Company Limited (GTCL) and the offshore IOC Cairn Energy. Present gas deficit restricts all kinds of new gas connections in Chittagong.

Gas is supplied to the Chittagong region from the National Gas Grid, operated by Gas Transmission Company Limited (GTCL), and from the offshore field Shangu (managed by Cairn energy). Shangu Gas field which until recently used to be the main source of supply to the Chittagong area is on the verge of drying up as its output is at a lowest ever level of around 29'500 Nm^3h. A decade ago, during initial production, Shangu had produced 259'600 Nm^3h.

Table 4 portraits the monthly average daily gas supply and demand scenario of the Chittagong gas distribution area. Presently, the gas deficit of Chittagong is partially mitigated by shutting down CUFL (Chittagong Urea Fertilizer Limited) or Raujan Power plant alternately and by restricting all kinds of new connections in Chittagong.

Table 4: Monthly average daily demand & supply of gas at Chittagong (in Nm^3/h)

Month (2009)	Ctg. Gas demand	Ctg. Gas available	Monthly deficit	Gas supplied by GTCL	Gas supplied by Shangu
December'08	371'721	273'488	98'232	212'093	61'395
January	376'186	281'302	94'883	217'674	63'627
June	378'418	271'256	107'162	217'674	53'581
July	417'488	267'907	149'581	217'674	50'232
November	417'488	258'976	158'511	217'674	41'302

Source: BGSL

[11] Nm^3/h stands for "normal" m^3/h, meaning under normal conditions of 1 bar and 20 Centigrades

Gas from the Bakhrabad gas field is distributed to the Dhaka region via the Bakhrabad-Dhaka pipeline and to the Chittagong region via the Bakhrabad-Chittagong pipeline. The gas supply from Bakhrabad and also from Shangu is transmitted to the ring main line of the Chittagong region from which any node or terminal can receive gas at a pressure of 350 Psig[12]. As of the 28th of February 2010, the gas reserve at Bakhrabad is 9858308 Million Nm^3 and it is being depleted at a rate of 1019376 Nm^3 per day. At this depletion rate, Bakhrabad gas reserve is expected to be fully exhausted after 26.5 years.

Natural gas is used to generate 75% of the total commercial energy of the country. Out of the 23 existing gas fields in the nation, the total estimate of proved and probable (P1+P2) reserve of gas is 596072850 Nm^3. As of June 2009, 39.76% (237013290 Nm^3) has already been extracted. Therefore, the estimated left over of reserve (P1+P2) is 359059560 Nm^3 (Table 5).

Table 5: Proven, Probable and Possible gas reserves in the nation

Type of Gas Reserve	Total Gas Reserve (Nm^3)	National Oil Company (Nm^3)	International Oil Company (Nm^3)
Proven (P1)	195'953'640	152'373'777	4'355'1546
Probable (P2)	147'814'740	97'042'360	50'800'700
Possible (P3)	198'502'170	96'645'921	101'884'566
Production per day (as of April' 09)		988'690 Nm^3/h	1'083'238 Nm^3/h

(***Source***: Petrobangla)

Projections from Petrobangla suggest that if the probable (P2) reserves can be converted to proven (P1) reserves then the remaining 237013290 Nm^3 can be utilized to supply gas till 2015. Subsequently, if the probable (P2) and possible (P3) reserves can further be converted to proved (P1) reserves, then the gas supply to the grid can be ensured till 2019.[13]

[12] Psig means "pounds per square inch gauge" and is measured as pressure above atmospheric pressure, 350 psig is equivalent to approximately 2400 kPa or 24 bar

[13] NTPC one of the national power giant of India so far submitted a proposal to Bangladesh Govt. for installing a 1320 MW imported coal based power generation near the different port location. They have selected a site along the bank of the river Karnafuly at Anowara which is very adjacent to KEPZ for setting up a 500 MW

3.4 Conclusions including recent developments

Natural gas is the major source of power generation in the Chittagong region. Due to present acute gas crisis in this region it is highly unlikely that the ever growing energy and power demand and supply gap will be mitigated in the prevailing condition. The present gas deficit also restricts all kinds of new gas connections in Chittagong.

The actual energy situation of Chittagong is not going to be changed overnight but some hints of hope from different corners may come out as fruitful options for the industrial sector in the near future. This can be discussed in light of the present initiative of the Government and Private sectors:

- It is encouraging to note that the Government of Bangladesh (GoB) has adopted "Policy guidelines for enhancement of private participation in the power sector, 2008" in order to augment generation capacity on priority basis[14]. One of the major initiatives resulting from the energy industry restructuring process is the evolution of merchant power plants. Merchant plants are defined as power generation facilities that sell all or a portion of their output in a competitive market, without the benefit of long-term contracts to provide a stable revenue stream. A private investor – such as KEPZ - may install such a plant inside their premise and sell the maximum portions to the outside customers/utilities until the sufficient internal demand builds up (see below figure).

- Cairn Energy, the operator of Sangu Gas Field, is expecting a huge amount of gas from the Magnama and Hatiya gas fields, when extracted these will definitely increase the supply in the gas grid especially in Chittagong Region.

- The Government has so far relaxed many conditions for HFO import by the private sector especially for power generation.

Combined Cycle power plant, will definitely rich the supply side of the Chittagong region power grid once installed.

[14] GoB desires to promote private investors to set up Commercial Power Plants/ Merchant Power Plant (MPP) (i) to supply electricity to large consumers on mutually negotiated tariffs; and (ii) to supply electricity to the Distribution Licensees at tariffs determined by the Bangladesh Energy Regulatory Commission (BERC).

Considering the geographical position of Chittagong, local industrial players can easily consider HFO as an alternative fuel source.

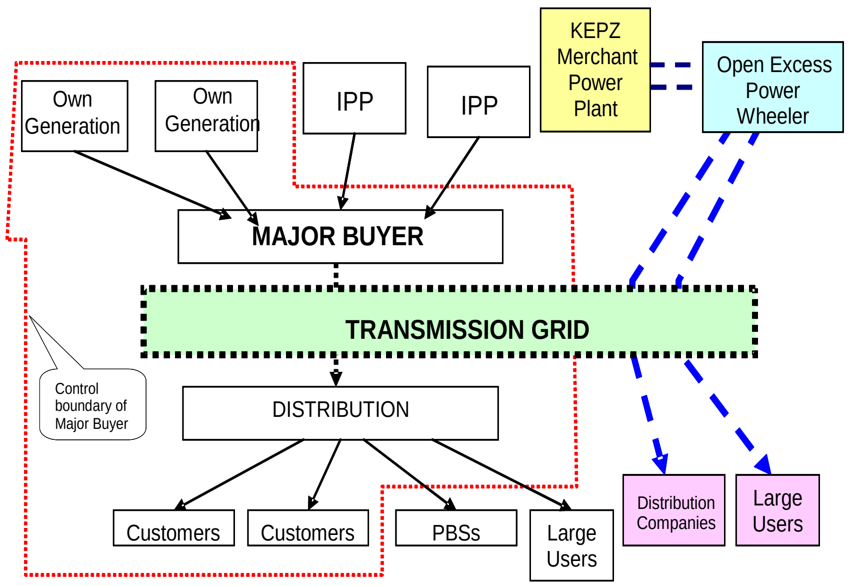

Figure 8: Open access arrangement for the private generator

In light of the above mentioned constraints KEPZ seriously has to not only to consider exploring all possible renewable and energy efficiency potential immediately but probably also to invest in its own power production to stay as much independent as possible.

4. KEPZ energy demand analysis

4.1 KEPZ baseline analysis on power requirement

4.1.1 Land use pattern of KEPZ

Zone Allocation plan of KEPZ:
Processing zone: 60%,
Non-processing zone including greeneries: 40%.

The entire area of KEPZ can be generally divided into two zones: Processing and Non-processing. The processing zone is consisting of individual industry plots whereas the non-processing zone includes all the other facilities of the EPZ. According to the master plan of KEPZ, area allocated for the industrial processing zone is almost 60% of the total area and the rest 40% comprises the non-processing area including the greeneries.

KEPZ also has plans to build one self-contained township with all necessary facilities for modern lifestyle such as hospital, educational institutions, banks, shops and recreation facilities like sports grounds, stadium etc. in KEPZ premises.

Processing areas are further divided into several industrial zones. Each zone is dedicated to a specific type of industry which incorporates plots of equal areas. However due to non-uniformity of the landscape of KEPZ, in some cases the entire area of the plot might not be suitable for construction. Area allocated for different types of industry and the distribution planning of the processing zone is attached in Annex-B.

4.1.2 Assumptive industries-mix

As per KEPZ master plan, the processing areas are further divided into small zones of cluster industries. Each zone is dedicated to a specific type of industry, which incorporates plots of equal areas. The textile industry is the most space consuming category with around $1.3km^2$. More detailed information about each category is attached in the Annex-B.

4.1.3 Estimation of power demand

Estimated power demand for KEPZ is 193 MW, of which only 16 MW is committed by BPDB.

In addition to the peak demand varying from factory to factory, it is unlikely that peak demand will occur in all factories at the same time. A diversity factor, which relates peak demand to rated/calculated demand, is utilized in computation of maximum demand. As industries become more mechanized, the demand would increase over time with higher technology machinery entering into the sector. This would increase the power demand in KEPZ gradually.

As per international standards, a power requirement of 450 kVA per hectare is considered for industries, 250 kVA for amenities, 300 kVA for staff quarters area, 35 KVA for road & utilities, 4 kVA for greeneries with a plot ratio of 0.7. Standard power requirements for different industries are given in the following table 6 and 7.

Two Broad power consumption categories are considered:

- Category-A-Processing zone of different Types of industries, table 6.
- Category-B-Non-processing areas like utilities, zone support services, administrative and other commercial buildings like entrance plaza for shopping, residential staff quarters and social amenities and recreational areas etc., table 7.

Table 6: Estimated Power demand of KEPZ (Category A)

Major categories of probable Industries	Total Land area in acres	Plot Ratio	Power Demand in KVA/ha	Power Demand in KVA/1000m^2	Power Demand in kW/acres	Diversity Factor	Allowance for Distribution system Loss	Adjusted MD in MW_e
Category-A								
A-Industries								
Shoe factory	100	0.75	300	30	115	0.7	1.1	6.661
Fabrics	64	0.75	450	45	173	0.7	1.1	6.434
Yarns	64	0.75	450	45	173	0.7	1.1	6.434
RMG	64	0.75	450	45	173	0.7	1.1	6.434
Agro-based Industries	200	0.75	300	30	115	0.7	1.1	13.321
Leather Goods	120	0.75	300	30	115	0.7	1.1	7.993
Light Engineering	50	0.75	300	30	115	0.7	1.1	3.330
Pharmaceuticals	60	0.75	300	30	115	0.7	1.1	3.996
IT/ITES Plots	50	1.90	1076	107.6	414	0.7	1.1	30.271
Hardware and Electronics	90	1.00	1076	107.6	414	0.7	1.1	28.678
MTB (for IT enabled services Like BPO, Call Center etc) (est.)	15	2.00	1076	107.6	414	0.7	1.1	9.559
Textile (Fabric Dyeing and Coating)	84	0.75	450	45	173	0.7	1.1	8.432
Light Chemical	150	0.75	300	30	115	0.7	1.1	9.991
Insulation (Polyfill) (est.)	20	0.75	450	45	173	0.7	1.1	1.998
Ceramic	50	0.75	450	45	173	0.7	1.1	4.995
Nylon & Polyester Weaving (est.)	64	0.75	450	45	173	0.7	1.1	6.434
Standard Industry building	47	1.60	450	45	173	0.7	1.1	10.018
Port related Services and business,ship chandler Items	20	0.75	300	30	115	0.7	1.1	1.332
Scientific measuring instrument and precision tools	25	0.75	300	30	115	0.7	1.1	1.665
Total Category A	**1339**							**168 MW**

Table 7: Estimated Power demand of KEPZ (Category B)

Major categories of probable Industries	Total Land area in acres	Plot Ratio	Power Demand in KVA/ha	Power Demand in KVA/1000m²	Power Demand in kW/acres	Diversity Factor	Allowance for Distribution system Loss	Adjusted MD in MW_e
Category-B								
G. Ware house	20	0.75	35	3.5	13	1	1.1	0.222
H. Zone support services	326							
Dormitory	10	0.5	300	30	115	0.7	1.1	0.444
Training	10	1	250	25	96	0.7	1.1	0.740
Zone administrative offices	11	1	250	25	96	0.7	1.1	0.814
Residential Housing area	172	1	250	25	96	0.7	1.1	12.729
Jetty and Backup facilities	80	0.75	300	30	115	0.7	1.1	5.328
Hospital	5	0.75	250	25	96	0.7	1.1	0.278
Social amenities (police post+firebrigade+post+ custom)	8	0.75	250		96	0.7	1.1	0.444
sports facilities+recereation areas+park	30	0.75	250		96	0.7	1.1	1.665
I. Commercial & CBD	20	0.75	300	30	115	0.7	1.1	1.332
L. Utilities (Gas, Water, Power)	81	0.75	35	3.5	13	0.7	1.1	0.629
M. Road	279	0.1	35	3.5	13	0.7	1.1	0.289
N. Greenery	59	0.1	4	0.4	2	0.7	1.1	0.007
Total Category B	**785**							**25 MW**
GRAND TOTAL	**2124**							**193 MW**

Diversity Factor: For KEPZ with light to medium type power intensive units, a diversity factor of 70% is normally considered adequate for computation of peak demand for the EPZ area. So, 70% diversity means that the device in question operates at its nominal or maximum load level 70% of the time that it is connected and turned on.

Losses: Power losses in the distribution network depend on the type of conductors and equipment installed. This is generally considered to be about 10% of the total load. A short summary on the estimated power demand is as follows.

Plot ratio: The **Floor Area Ratio (FAR)** or **Floor Space Index (FSI)** is the ratio of the total floor area of buildings/industrial floor space on a certain location to the size of the land of that location, or the limit imposed on such a ratio. The standard plot ratio for different industries or

Formula used to derive maximum demand for each type of industries and other non-processing areas = (Standard kW/acre consumption of each industry)*(total area demarcated for each type of industry as per zone planning)*(Plot ratio[i])*(Diversity factor[15])*(Loss factor) kW_e

The results indicate a total estimated power demand for processing areas of 168 MW_e. Additionally there is a total estimated power demand for non-processing areas of 25 MW_e and the total combined power demand for processing and non-processing areas is therefore estimated at 193 MW_e

4.1.4 Estimation of gas demand for selected industries

Estimated annual gas demand for selected industries at KEPZ:

311197 m3 per day

102 Million m3 per year

Gas is a key ingredient for many process industries. We have selected some industries with significant gas consumptions from a list of probable industries to estimate the major usage of gas. Total Gas requirements for different industries on basis of the operation hours have been depicted in Annex-C.

- Total Gas requirement of the selected industries (m^3/day) **– 311197 m^3 per day**
- Total Gas requirement of the selected industries- **102 Million m^3 per year**

4.2 Conclusions

In assessing the total energy demand for the entire zone, the industry mixes considered are small to medium high energy intensive. We found the demand for energy (both power and gas) highly depending on the industrial mix. The demand analysis shows some estimation on the requirement of power and gas is as follows.

- We have derived a figure of approximately 193 MW as total demand of KEPZ against the total commitment of only 16 MW guaranteed so far from BPDB, which is roughly around 8% of the total power requirements. Approximately 177 MW of electrical power is still required to make the zone fully functional

- The estimated annual gas demand for the selected industries at KEPZ is estimated at roughly 102 Million m^3 per year

The intended industrial mix with industries like textiles, steel and gas based petro-chemicals are really energy intensive and hence careful considerations have to be taken by the zone authority before allowing tenants from the respective energy intensive categories. If we consider the present countrywide power scarcity, BPDB and gas utilities might not be able to provide the energy demand of KEPZ in the near future.

It is therefore concluded that KEPZ must stride forward with this issue to ensure the best potential energy alternatives for making the zone self-sufficient on energy supply.

5. An assessment on Renewable Energy options for KEPZ

5.1 Hydro Power Potentials[16]

The hydropower potential within and around KEPZ can be subdivided into four different components. These are briefly discussed below.

5.1.1 Streams and rivers within KEPZ

Unfortunately, there are no significant rivers or streams within KEPZ. A few very small streams connecting individual ponds have flows of a few l/s (less than 20 l/s per visual guess), but are possibly not even permanent. The overall head which could somewhere be utilized is strictly limited by the elevation difference of the KEPZ terrain to the ocean and lies somewhere between 20 and 30 m. It can therefore be concluded that there is no potential for run-of-river (meaning without storage) hydropower.

There is hardly any potential identified for run-of-river (without storage) hydropower near KEPZ

5.1.2 Ponds within KEPZ

There are approximately 20 ponds distributed over the KEPZ area which are fed from surface runoff and groundwater. They are not systematically interconnected. The total volume of the ponds has been estimated from the general KEPZ layout to 4.5 Mio m^3. If it is assumed that the average head between the ponds and the ocean is approximately 20 m, the total storage in the ponds represents around 245 MWh. This means that the total future power demand could be covered for approximately one hour with one complete fill of the ponds, or a permanent power generation of around 30 kW could be provided under the assumption that the ponds are being filled once a year. This is only a theoretical analysis. Practically, a complex system of interconnecting pipelines and a very small power plant approximately at the elevation of the ocean would have to be built. This is not feasible either technically or financially. Also it would reduce the ecological functionality of the ponds. It is therefore concluded that the ponds do not provide any usable hydropower potential.

The ponds do not provide any usable hydropower potential

[16] The following content is based on the internal work report – see table of references – by Dr. K. Jorde from entec Ltd..

5.1.3 Karnafuli River

The Karnafuli River flows nearby the KEPZ into the Bay of Bengal. 50 km upstream of Chittagong is the 230 MW Kaptai hydropower plant (HPP), a multipurpose dam and reservoir for hydropower, flood management and irrigation. Further downstream nearby KEPZ the gradient of the river over becomes very small and there is no head available for a traditional run-of-river HPP. Moreover, building any dam or weir to elevate the upstream water level would immediately submerge large areas of land. Installation of flow converters in the river is also considered as an unfavourable technology due to too small flow velocities (1-2 m/s), sandy bottom of the river causing unfavourable conditions for placing flow converters and the bidirectional flow of the river, depending on the tide. The generation would not be continuous, but would follow a sinus function. Rated power would be in the range of some hundred kW at maximum. It is therefore concluded that the Karnafuli River cannot provide any electricity for KEPZ from hydropower.

The Karnafuli River cannot provide any electricity for KEPZ from hydropower due to small flow velocity

5.1.4 Tidal power plants

Older tidal power plant technology is not feasible for the mouth of the Karnafuli River when the difference between the low and high tides is only 2-3m (against a standard of at least 8 to10m). Also, a dam would generate multiple problems with navigation and other issues. New types of tidal power plants are utilizing so-called flow converters that stand in the water and can be placed in any kind of unidirectional river current or ocean current. But since this technology is not yet established and there is no knowledge available about tidal currents or ocean currents near KEPZ, this technology is not considered promising. The same applies for wave generators as they are developed as prototypes along coasts with heavy wave action.

Since this technology is yet to be established and there is little knowledge available about tidal/ocean currents near KEPZ, this technology is not considered promising.

5.1.5 Power from waste water

Utilization of the water used within KEPZ and discharge into the Karnafuli could be done by installing a micro-hydropower plant using the head between KEPZ and the ocean/river. It is estimated that by 2030 the water use will be 100'000 m^3 per day. If this water is released to a wastewater treatment plant, the flow would be 1.15 m^3/s.

It might make sense to know about the economic feasibility of this option, but it would represent an insignificant contribution to the energy supply of KEPZ

Assuming a head of 30m, this water could produce approximately 250 kW. However, while it might make sense to know about the economic feasibility of this option, it certainly would not represent a significant contribution to the energy supply of KEPZ. Additionally, the consideration to release all water used in the KEPZ to a waste water treatment plant and ultimately into the Karnafuli River, would not necessarily represent renewable energy because the water may have to be pumped to the KEPZ elevation level before it can be used. Only a part of this energy can be regained.

5.1.6 Thermal ground water use

Groundwater in KEPZ is available in 15-20 m depth, but it is warm (29-30ºC). For utilization of groundwater for “natural” or “passive” cooling, the temperature of the groundwater must be lower. A temperature of 16 – 18°C is feasible to run cool water through pipes in concrete slabs or walls to cool the buildings. Another problem in countries like Bangladesh is that, because of the high moisture content of the ambient air, the air inside the building would have to be dried first. Otherwise there would be condensate on the cooled surfaces. If the air needs to be dried first, even cooler groundwater is needed, 8-10°C preferably. Hence, although it would be an inexpensive option, as the groundwater temperatures are too high, it is considered not feasible.

> Although it was an inexpensive option, as the groundwater temperatures are too high, it is considered not feasible.
>
> In situations like KEPZ where there is abundant solar heat available, there is possibility of using absorption chillers. However, the required investment for the technical equipment needed is rather costly.

Another option to use groundwater for cooling is “active cooling”. In this case a reversed heat pump or chiller is used which consumes electricity. In situations like KEPZ where there is abundant solar heat available, there is a possibility of using absorption chillers. This type of chiller uses heat instead of electricity to drive the heat exchange between the groundwater (or another cold source) and the air in the buildings.

Absorption chillers are driven by hot water that may come from any number of industrial sources or from solar heat. The temperature needed for the hot salt solution is 80 – 90°C. It should be technically possible to generate this temperature by using solar heat, however, the required investments into the technical equipment needed is rather costly.

1.

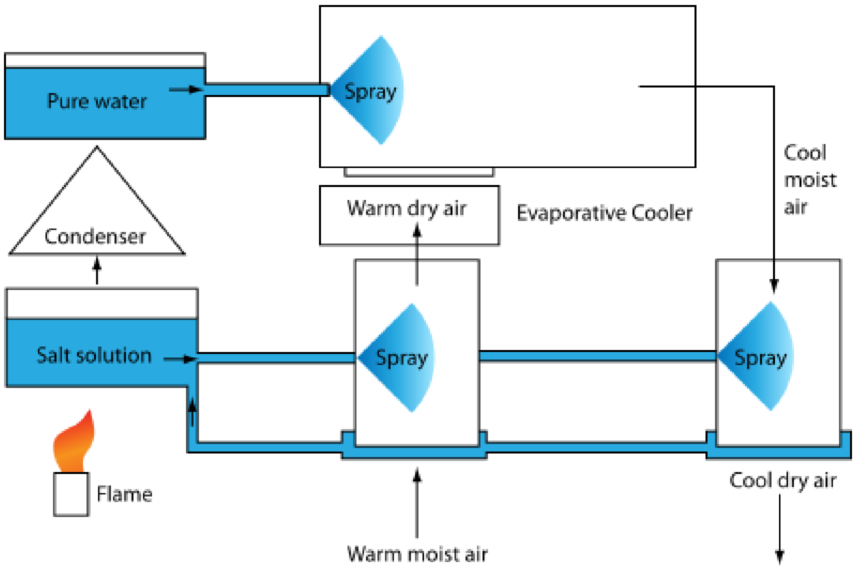

Figure 9: Absorption chiller scheme

5.1.7 Conclusion

There is hardly any potential identified for run-of-river hydropower, power from the ponds and the Karnafuli river.

Since tidal power technology with a low height difference between the high and low tides and therefore using tidal currents only is yet under research and there is little knowledge available about local tidal/ocean currents near KEPZ, this technology did not come out as promising.

Power generation from waste water could represent a viable but insignificant contribution to the energy supply of KEPZ.

Thermal ground water use would be an inexpensive option for cooling. As the temperature of groundwater is too high this is not considered feasible as well.

Using absorption chillers taking the warm ground water could be a feasible option but initial investment would be considerably higher than the conventional one.

5.2 Biomass

5.2.1 Biomass resource in KEPZ[17]

There are a total of 100 hectare paddy fields cultivated around KEPZ resulting in 200 tons of straw and 80 tons of rice husks annually. From more than 1’000 livestock units (LU) in a cattle breeding unit in KEPZ around 15’000 m^3 manure will be available per year.

The annual biomass-flow is around 18’742 tons with 12.4% dry-matter resulting usable organic dry matter, around 1’819 tons per year.

From 10,000 workers accommodation In KEPZ, 730 tons of organic household residues and 2,600 tons of fecal matter of 25,000 workers (312 working days considered) are taken into account. Kitchen residues for YO in KEPZ as well as CEPZ is taken into account and shown in the table of Annex D on basis of the data collected for the year 2009.

There is a large amount of natural landscape in KEPZ which could be used as source of garden residues and so on and indicated in the table of Annex D.

Almost all of the YO-factory residues are declared as non-organic matter and may not be lucrative for direct-consumption. The only organic matter coming out of the YO-factory is a semi-solid sludge from the effluent treatment plant (ETP) with an amount of 240 tons in the year 200 but declared as hazardous. Waste from production facilities is not shown in the table since it is not yet finalized which type of factories will be in what quantity in KEPZ.

For the energy generation, only organic content has to be considered and the table is based on in-house biomass resources. As shown in Annex D the annual biomass-flow mobilized over YO, is around 18’742 tons. The mixed up biomass would have a dry-matter quotient of 12.4%. This means that almost 87.6% of the Input-Matter is made of water. The reason for this high amount of water content comes out of the slurry of cattle breeding which makes up the largest share of the biomass.

If annually 40,000 tons of municipal waste is collected from Chittagong municipality and added with KEPZ biomass residues, the potential CHP capacity would be 1’035 $kW_{el.}$ and 1’129 kW_{th}.

[17] The following content is based on the internal work report – see table of references – by O. Deiss und P. Jeitz from Holinger Ltd..

The usable organic dry matter, which is fundamental for the recovery of energy amounts to around 1’819 tons per year.

5.2.2 Energy assessment

The available organic residues are not coming from a single source and they have a high water content for which the only solution might be the anaerobic digestion. The estimated potentials are calculated based on the experiences of local large-scale plants and on different bibliographical reference. For purposes of comparison with other renewable energy sources (wind, solar, water) it is assumed that the biogas is used in a commercial CHP-plant (combined heat and power).

a. Potential without external biomass (assessment A)

The biogas yield being 23 Nm^3 per ton substrate-mix, the CHP potential is around 114 $kW_{el.}$ and $kW_{th.}$ Slurry of the cattle breeding makes about 70% of the total input-material. For this reason, it should be reasonable to site the biogas plant close to cattle breeding. Refer to Annex-E.

From only in-house biomass residue, estimated capacity of CHP would be 114 $kW_{el.}$ and 125 kW_{th}.

b. Potential with external biomass of the city of Chittagong (assessment B)

Chittagong, a metropolis with a population of over 2.5 million people is located approximately 10 km from the site of KEPZ. Considering each inhabitant of Chittagong produces an average of 80 kg of household residues per year, more than 200’000 tons of municipal residues are generated annually in Chittagong city. In this assessment, a part of the total waste i.e. 40’000 tons of municipal waste is assumed to be collected and transported out of the city (130 tons per day, calculated based on 6 working-days per week) to be treated in a large scale plant for energy generation purpose. The biodegradable part of the municipal waste in Bangladesh is between 70 and 80%. That will bring around 30’000 tons of additional organic residues for the bioreactor.

Combined with the organic residues of YO, the biogas yield in assessment B is around 119 Nm^3 per ton substrate-mix. The surplus in comparison to assessment A comes of the higher amount of organic matter. The theoretical average power in assessment B is around 1'035 $kW_{el.}$ and 1'129 $kW_{th.}$

It should be kept in mind that it is often complicated to ensure the supply of municipal waste from external sources and a number of issues are involved rather than technical and commercial feasibility only. Besides, the plant should be somewhere close to the city to keep the transit routes minimized. In this assessment, municipal residues are used to substitute the different substrate from the site of KEPZ with the exception of rice straw. Some components of the waste, which have to be separated on-site, could be collected and sold as recycling raw material.

5.2.3 Conclusion

The annual biomass-flow from KEPZ is estimated at around 18'742 tons with 12.4% dry-matter, resulting in usable organic dry matter of around 1'819 tons per year. It should be possible to collect a part of this biomass for producing biogas.

If annually 40,000 tons of municipal waste are collected from Chittagong municipality and added with KEPZ biomass residues, the potential CHP capacity would be 1'035 kW_{el} and 1'129 kW_{th}.

From only in-house biomass residue, estimated capacity of CHP would be 114 kW_{el} and 125 kW_{th}.

Biomass use for combined heat and electricity generation might be a viable option but will not provide any significant contribution towards meeting the electricity and heat demand for KEPZ in the future. This includes the option where municipal waste is collected and brought to the biomass processing plant.

5.3 Solar Thermal

5.3.1 Introduction[18]

An investigation is done for both low and high temperature solar thermal applications at KEPZ (see figure 10). Solar thermal energy could contribute to supplying the shoe production as well as related facilities (i.e., the kitchen for the preparation of employee food and the dormitory for office staff). While standard non concentrating collectors are sufficient for low temperature applications, systems concentrating the sunlight are required for high temperature solutions. In case of electricity generation we assumed the installation of a parabolic trough power plant – the current incumbent technology with the lowest levelized cost of electricity in the field of concentrating solar power (CSP). A linear fresnel plant is assumed to be the best performing option for the generation of process steam at temperature levels required for shoe production at KEPZ (ca. 150° C).

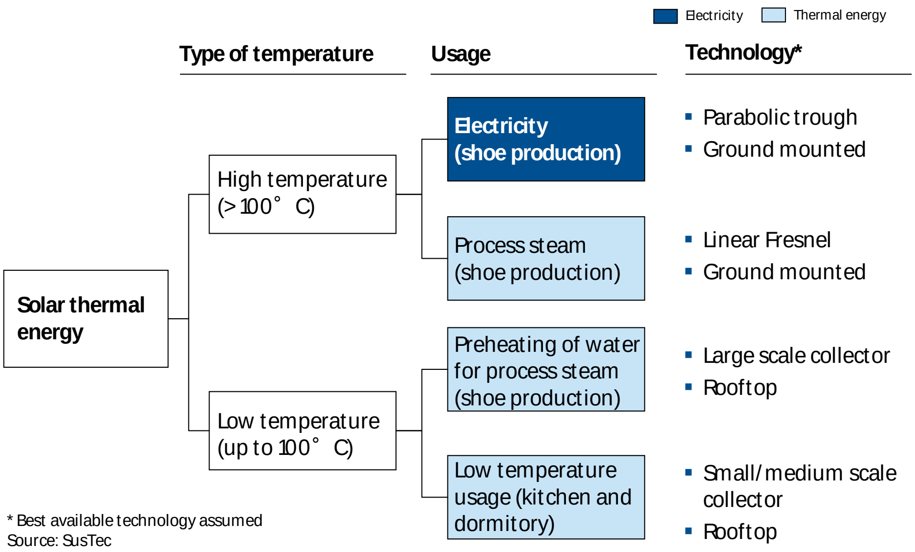

Figure 10: Potential opportunities of solar thermal energy at KEPZ shoe production

Solar thermal energy use at KEPZ shoe production is not attractive in financial returns, primarily due to heavily subsidized fuel price in Bangladesh and direct normal irradiation being very less during May to September.

Generation of hot water for dorm facilities is the most attractive amongst the assessed options and would be economically viable if an investment subsidy of 30% is aided for promotion of renewable energy

[18] The following content is based on the internal work report – see table of references – by T. Schmidt and M. Peters of ETH Zurich.

5.3.2 Assessment of low temperature applications

Generation of hot water for dorm facilities

A replacement of hot water heaters in the dormitories for managers is considered with solar thermal heaters where more than 200 m^2 of shadow-free surface is available in the roof top. Assuming a shower temperature of 40°C and about 40 people showering per day, annual energy savings would amount to 5 MWh_{th}.

Key assumptions

- Global annual irradiation: 1,950 kWh/m^2
- Heating of shower water to ~40° C
- Temperature of fresh water: ~ 30° C
- 40 people showering per day (30 l p.P.)
- Baseline: electric flow heaters (80% from grid, 20% from gen-set)
- Energy costs
  - Grid electricity: 67.00 USD/MWh
  - Diesel: 0.64 USD/l
- Efficiency of flow heater: 96%
- Efficiency of STH: 20%
- Inflation 3%

Sources: Kaltschmitt, KPEZ team, NLWKN, SWERA

Results

- IRR: 0.5%
- Total investment: ~8,500 USD
- Energy savings p.a.: ~5,100 kWh
- GHG abatement p.a.: ~3.6 t CO_2e
- Area needed: ~13 m^2 (easily installable on roof top)
- Potential low-tech solution could reach higher IRR (~5%)
- Such solution financially attractive (10% IRR) with ~30% investment subsidy

Caveat: rough estimate of amount of showers per day

Figure 11: Solar thermal water heating for dormitory

Generation of hot water for kitchen facilities

A solar hot water system (SHW) could preheat water up to 90°C. Assuming 30'000 workers consuming 30'000 meals per day and further assuming that 1 l of boiling water per meal is needed, more than 650 MWh_{th} per year could be saved in the kitchen.

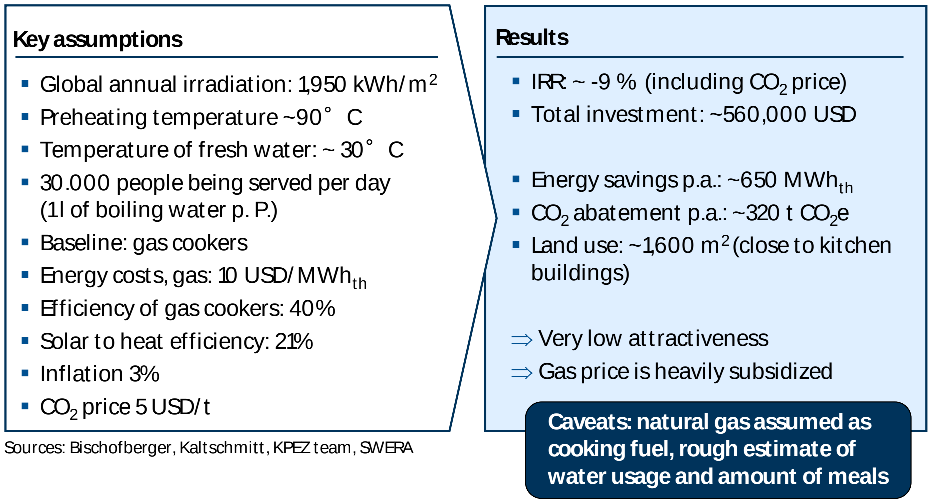

Figure 12: Solar thermal water pre-heating for kitchen

Preheating of water for process steam

Highly efficient non-concentrating solar heating systems usually operate at a temperature of about 90 to 120°C. Cheaper, less efficient collectors run at temperatures of up to 90°C. For two reasons these applications are not suitable for preheating of process steam at KEPZ shoe production. First, the return temperature of the condensate in the process steam cycle amounts to about 85°C, which would result in a maximum temperature difference of 5° C – 35° C. This delta is too low especially as the water might not be heated but cooled down in the collectors on days with low irradiation (e.g., during the monsoon months). Second, the amount of fresh feed water (at 30°C), which would benefit from preheating, is assumed to be very low (<10%), as the system is run as a closed cycle.

5.3.3 Assessment of high temperature applications

Concentrating solar power (parabolic trough)

In particular for low direct normal irradiation during the summer months (May to September) the levelled cost of energy (LCOE) is fairly high, for a 10 MW CSP plant around 0.40 USD/kWh. Therefore this is not a financially viable option for electricity generation at KEPZ (see figure 13).

Key assumptions
- Total investment costs: 4.5 USD/Watt (excl. storage)
- Plant lifetime: 30 years
- Annual O&M costs: 2% of total investment costs
- Annual direct normal irradiation ~ 1,500 kWh/m²
- 10% discount rate p.a.

Performance dimensions	Assessment	Viability (yes/no)
Levelized cost of electricity	▪ 40 USD cents/kWh ▪ Cost significantly above conventional power generation	X
Time to operation	▪ ~ 3 years ▪ 25 MW_{el} needed within next 2 years	X
Site requirements	▪ ~ 0.5 km^2 of plain land (5% of entire KEPZ)	(✓)
Intermittency	▪ No/very little power available May – Sept.	X

Source: Energy Plus weather data, SusTec LCOE model

Figure 13: CSP solution to produce electricity at KEPZ

Generation of process steam (linear fresnel)

A linear fresnel plant generating steam yields cost significantly above the benchmark of fossil fuels (5.5-6 USD cents/kWh_{th})[19)].

5.3.4 Conclusion

Currently, opportunities in the field of solar thermal energy use at KEPZ shoe production are rather limited since the assessed options do not yield attractive financial returns. This is primarily due to two reasons. First, fossil fuel prices in particular gas are heavily subsidized in Bangladesh. Second, the solar resource in the Chittagong area is generally attractive, yet, between May and September in particular direct normal irradiation required for concentrating solar thermal plants drops significantly.

Generation of hot water for dorm facilities is the most attractive amongst the assessed options. An investment subsidy of about 30% (e.g., provided by a development aid agency) would make this project economically viable. Such a small scale solar collector could serve as a demonstration project, which would yield valuable insights regarding the future use of solar thermal energy at KEPZ and the Chittagong

[19] Source: SusTec Linear Fresnel cost model, Technology Innovation Report CSP (2008) Key assumptions: Cost of solar field 235 USD/m2, plant lifetime 25 years, discount rate 10% p.a., solar to steam efficiency 35-40%, O&M cost 2% of investment cost p.a.

area. Offers from local producers should be inquired as they might differ from our assumptions due to low local labour costs.

Although currently the economics of solar thermal systems are not sufficient to deploy them at scale at KEPZ this might change in the future as solar thermal system costs decrease and fossil fuel prices increase.

5.4 Solar Photovoltaic

5.4.1 Introduction[20]

As the energy crisis is increasing alarmingly, industries can explore alternative energy sources for smooth operation during long power-cuts. Installing grid connected solar solutions. KEPZ can offset a certain percentage of total power requirements and contribute a significant portion to some sort of KEPZ hybrid grid. KEPZ shoes has 48,384 m^2 (including factory building and warehouse) of roof space available. Considering 80% of the total available roof space 38700 will be able to generate approximately 3470 kW.

Among different types of solar solutions grid tied system is particularly suitable for KEPZ. This system is especially suitable where the grid exists and can play as an alternative source of power to the grid where it is connected on a continuous basis.

[20] The following content is based on several internal work reports – see table of references – from the RREL-team.

5.4.2 Types of solar solution in practice

Solar photovoltaic (PV) systems are like any other electrical power generating systems. In solar PV system equipment used is different than that used for conventional electromechanical power generating systems. However, the principles of operation and interfacing with other electrical systems remain the same.

There are different arrangements nowadays available to generate power from solar systems.

Stand-Alone systems: This refers to a solar power system converting solar energy to electricity without having any supporting connectivity with a grid or other power sources. This system is more appropriate for light loads and where uninterrupted power supply is not a prime concern.

Hybrid systems: This refers to a solar power system that is connected with the grid or other back up power generators so that solar batteries can be charged by solar energy as well as from other connected power sources when required. It is basically a dual power system which provides uninterrupted power supply switching from primary solar energy mode to back up grid electricity or diesel generator when it is needed.

Solar grid tied solution: This is especially suitable where the grid exists and can function as an alternative source of power to the grid where it is connected. This system has no battery backup and hence is free from routine maintenance and expensive storage media. The main component of this system has an array of solar panels and inverter to convert DC to AC power. It is a standalone system when connected with the distribution grid capable of supplying whatever power it produces during the day time. The system is less expensive than the two other systems mentioned above and particularly suitable for KEPZ to offset certain amounts of power requirement on a continuous basis. The typical schematic diagram of a solar grid tied solution is given in figure 14.

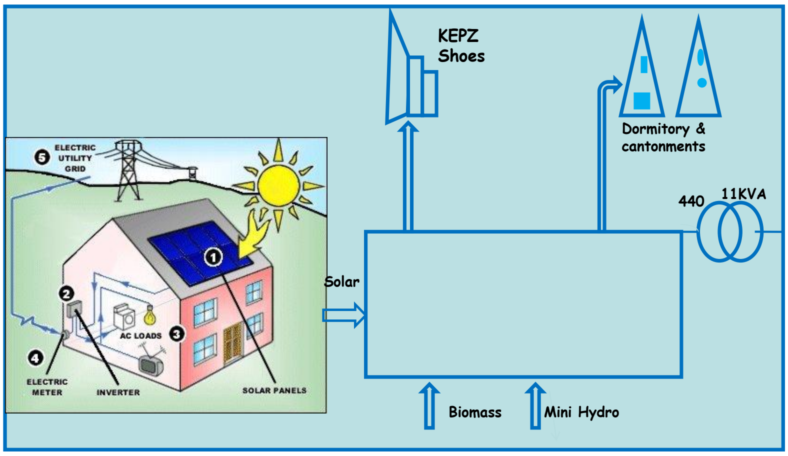

Figure 14: Schematic diagram of solar interactive Grid

5.4.3 Application and implementation of solar energy in KEPZ:

Potential facilities:

The most attractive and feasible solar solution for KEPZ is to provide the lighting loads for the following facilities:

- Factory lighting loads
- Dormitory and cantonment
- Administrative building
- Warehouse
- Periphery and emergency lighting in the KEPZ premises
- Lighting loads for sports fields, golf course and other entertainment facilities
- Lighting loads of hospital, bank, educational institution etc.

Solar lighting solution is considered as the most attractive and feasible option for KEPZ. Other light-duty electrical loads like ATMs, laptops, computers, printers etc are also favorable

There are also a few other possibilities for solar energy solution:

- Energy for the ATM's
- Energy for laptops, printers, etc. in the administrative buildings
- Emergency lighting

Building design considerations:

The most effective roof structure is flat and inclination of the PV array is 22 to 23° facing south

For the case of KEPZ, to attain maximum efficiency of PV modules for generating electricity for a maximum number of days in a year, the most appropriate roof structure are flat roofs and the PV array should be installed in an angle of 22 to 23 degrees facing in southward direction. The frame of the mounting structure is made of galvanized steel and can sustain a wind velocity of up to 200 m/s. However, if the roof structure is dome shaped or slanted in two sides, special mounting arrangements are required for efficient application of solar PV modules on the roof so that it can be installed facing the south direction with the optimal angle.

Load design considerations:

We have examined the load data provided by Youngone Shoe industries at CEPZ and found that about 6% of the total electrical load is used for lighting (please refer to Annex-F). In reference to that, we assume the same percentage for KEPZ and recommend catering that load by solar power. Youngone Shoe Production has a total load of 2745 kW of which a feasible solution of approximately 158 kW load (about 6% of total load) can be supported by solar energy that includes lighting, ceiling and pedal stand fans, exhaust fans, hot air blower, computers etc. Similarly for KEPZ shoes, 6% of total load 6660 kW (estimated) is approximately 400 kW load running for 9 hours (3600 kWh) during the factory operating time per day. To obtain equivalent amount of power from solar grid tied solution, approximately a 1455 kW_p PV solution has to be installed. However, as we recommend grid-tied solution for KEPZ, there will be no requirement of expensive batteries and it will be able to deliver 3600 kWh equivalent of energy during its insolation period (sun-hour of average 4.5 hours per day for Bangladesh). To install the same capacity system a roof space of around 16216 m^2 (about 4 acres) is required and should be made available.

In KEPZ shoes, the optimum design will cater 400 kW load running for 9 hours daily during the factory operating time (Equivalent to 3600 kWh of energy). To obtain this, approximately a 1455 kW_p solar grid tied solution has to be installed, which requires a roof space of around 16216 m^2

5.5 Financial analysis of recommended solar solution

The following part depicts a financial analysis of the recommended solar solution for KEPZ. This analysis can be taken as an example and used as a reference model for the financial analyses of other recommended renewable energy solutions. The snap shot of the model along with key financial figures is given below.

Table 8: Financial Summary of Solar Test Application

Comparison of Cost of Generation from Solar and Diesel

Assumptions	Interest rate: 8% for Solar, 13% for Diesel; Yearly inflation: 7% p.a																			
Solar-Grid Tied solution																				
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment including panels,inverter,cables and accessories	389,886,364										51,637,723									
Fuel	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Repayment on Investment	46,483,652	46,483,652	46,483,652	46,483,652	46,483,652	46,483,652	46,483,652	46,483,652	46,483,652	46,483,652	6,156,435	6,156,435	6,156,435	6,156,435	6,156,435	6,156,435	6,156,435	6,156,435	6,156,435	6,156,435
Yearwise cost of Generation	39.13	39.13	39.13	39.13	39.13	39.13	39.13	39.13	39.13	39.13	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18	5.18
Lavelized cost of Generation	**28.38**																			
CDM Revenue Expected	0.91	BDT/kWhr	From CDM																	
Expected Feed in Tariff for [using Renewable Energy	27																			
Total Cost of Generation	**0.5**	BDT/kWhr																		
Diesel Solution																				
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Investment on Genset inclsuding installation	5,500,000														14,181,938					
Yearly Fuel charge	16,727,040	19,863,360	19,150,788	19,150,788	19,150,788	23,460,539	23,460,539	23,460,539	28,740,169	28,740,169	28,740,169	35,207,943	35,207,943	35,207,943	43,131,244	43,131,244	43,131,244	52,837,628	52,837,628	52,837,628
Maintenance Cost	0	42,800	45,796	49,002	52,432	56,102	60,029	64,231	68,727	3,033,458	78,686	84,194	90,088	96,394	103,141	110,361	118,087	126,353	135,197	144,661
Yearwise fuel component on [cost of generation	14.08	16.76	16.16	16.16	16.16	19.80	19.80	19.80	24.25	26.75	24.26	29.71	29.71	29.72	36.39	36.40	36.41	44.58	44.59	44.60
Investment repayment	1,013,593	1,013,593	1,013,593	1,013,593	1,013,593	1,013,593	1,013,593	1,013,593	1,013,593	1,013,593	862,456	862,456	862,456	862,456	862,456	2,613,583	2,613,583	2,613,583	2,613,583	2,613,583
Yearwise investment part on cost of generation	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.73	0.73	0.73	0.73	0.73	2.20	2.20	2.20	2.20	2.20
Year specific cost of generation from Diesel	14.93	17.61	17.01	17.01	17.02	20.65	20.65	20.66	25.10	27.60	24.98	30.43	30.44	30.44	37.12	38.60	38.61	46.78	46.79	46.80
Levelized cost of Generation	**22.31**																			

Considering the nationwide energy crisis, solar energy can be opted as one of the viable alternatives if this is compared to diesel based generation in the long run. Although solar installation cost is way higher than diesel gensets, it has no fuel requirement as in the case of diesel and can be managed with little maintenance. Moreover some additional benefits like Carbon Benefits and feed in tariff can bring down the cost of generation significantly.

Cost benefit analysis of diesel generation shows that the levelized cost of generation from diesel is about 22.31 BDT/kWh for 20 years at an inflation rate of 7% p.a. and interest rate of 13% p.a. On the other hand, for the solar option with the same inflation rate and probable soft financing (7~8%), the levelized cost of generation for 20 years is about 28.38 BDT/kWh. However, if Clean Development Mechanism (CDM) is tagged into this, the generation cost for 1 kWh of power generated from solar system can be reduced by about 0.91 BDT. In addition to this, if feed-in-tariffs (FIT) are introduced in Bangladesh, it will also reduce the cost dramatically by increasing the revenue. FIT is already introduced in our neighbouring country India, where the Indian government is paying a tariff fixed by the Central Electricity Regulatory Commission (CERC) of India to the renewable project implementer. The tariff for such type of solar PV projects is fixed at USD 0.397/kWh which is equivalent to 27 BDT/kWh as per present currency exchange rate. The Government of Bangladesh is seriously thinking to introduce FITs for renewable energy generation. However, if FIT is introduced in Bangladesh, it can then help reducing the cost to even 0.5 Tk/kWh.

At 7% inflation rate p.a and probable soft financing at 7%~8% interest rate p.a, the levelized cost of generation for 20 years from solar is about 28.38 BDT/kWh. However, if Clean Development Mechanism (CDM) and Feed-In-Tariff (FIT) are tagged into this; it will reduce the cost dramatically

However, this benefit would only apply if KEPZ is operating public grid connected and sells the solar electricity to the public grid. In such a case the solar generation would be entirely its own business. If KEPZ generates its own electricity for self-consumption, FITs are not applicable.

5.6 Wind Power

Wind power, although possibly an important source of renewable energy, was not analysed in the study. It was excluded from the beginning because of missing wind data.

5.7 Main conclusions regarding the potential of renewable energies for KEPZ

Renewable energies are and will stay as complementary energy source for power generation. Due to the highly subsidised non-renewable fuels, the investment for renewable energy stays high, the economic viability stays constrained.

Biomass may be an interesting option but only by integrating the waste of the entire or most of the Chittagong city. Technically this is not a huge problem, but there are still many questions unattended. To whom the city waste belongs, how the waste can be collected from the respective authorities and how the waste will be transported to KEPZ are definitely some of the big concerns.

There is of course some industrial potential in the solar and solar heat especially in the field of pre-heating, which may be interesting in certain industries such as shoe-production.

For KEPZ the overall potential of renewable is small. But as KEPZ wants to position itself as a “green industrial zone” some complementary investments can make it more lucrative to the global stakeholders. Additionally KEPZ as a whole, has a pretty high potential of earning carbon revenue from its green initiatives under Clean Development Mechanism (please refer to the chapter 8).

Excursus: analysis of other fuel options for KEPZ

KEPZ is moving forward to develop the economic zone in a phase of massive prevailing energy shortage throughout the country. Right now the zone authority must carefully consider all the possible energy alternatives available ahead of them knowing that this will definitely has to include non-renewable energies. So it is highly important for KEPZ to establish a reliable and sustainable energy source, if necessary also including non-renewable energy, in order to ensure the energy security for the entire zone.

This part of the report outlines the potentials of using conventional non-renewable energy sources like natural gas and other commercial fuels like coal, LNG, and HFO in respect to KEPZ.

Natural Gas:

Natural gas is the primary fuel for power generation in Bangladesh as it is used to generate 91 percent of the total power nationwide. The power sector is under severe crisis due to the ever-increasing demand-supply gaps. Currently, Bangladesh has a total installed power generation capacity of about 5,500 MW. Aging power generation equipment, rapid depletion of natural gas country’s natural growth and poor demand forecasting are restricting the current maximum generation to about 4,900 MW with an average routine generation of about 3,600 MW. On the other hand existing gas reserves will be able to cater the gas demand growth of 7% per annum only up to year 2016. The current average daily gas production is about 50 Mio m3 (1970 MMCF[21]) against actual demand of 56 Mio m3 (2200MMCF) resulting deficit of around 6 Mio m3 (230 MMCF) per day. Due to this gas shortage about 500-900 MW of existing generation capacity is lying idle. So the existing gas supply will not be able to meet the expected gas demand of KEPZ and hence diversification of energy source and modes should be an intrinsic agenda.

Countrywide average gas deficit: 230 mmcfd
Demand: 4000 mmcfd
Production: 1900 mmcfd.

Existing gas reserve and projected supply will not be able to meet the national requirement.

[21] MMCF is standing for “mill mill cubic feet” or Mio cubic feet.

Coal:

Coal is likely to become an important commercial fuel in Bangladesh over the coming decades. In order to develop the sector in an efficient manner it is important to build capacity and awareness about coal technologies and it is high time to shift towards coal based power generation. Moreover It could provide up to 2500 MW capacity (About 25% demand of Bangladesh in 2015). But unfortunately there are no serious efforts yet for commercial recovery of these indigenous resources. As of now only one underground coal mine in Barapukuria, Dinajpur with annual production capability of 1 Mt is supplying the mine mouth power plant with a generating capacity of only 250 MW.

Coal likely to become an alternative of gas in near future of Bangladesh is yet to be developed efficiently in terms of policy, technologies and capacity.

Coal discoveries in the country seem to offer a solution for this with total mineable reserves of 1418 Mt. But to supplement the huge short supply of gas based power underground mining technology would not be enough as coal production from an underground mine is limited and cannot be drastically increased. The alternative therefore would be to go for large scale open pit mine with high annual output. Annual production targets for such mines can be set to 5 or more Mt to broaden the local market for coal based generation. Serious efforts are needed to be initiated without further delay for exploitation of country's discovered coal fields aiming to achieve large coal production and generation of coal based power.

Nationwide coal reserve table is attached in Annex-G.

LNG:

LNG is principally used for transporting natural gas to markets, where it is re-gasified and distributed as pipeline natural gas. LNG offers an energy density comparable to petrol and diesel fuels and produces less pollution. Considering the gas scarcity, the Government is seriously thinking to import Liquefied Natural Gas (LNG) from other countries. Preparatory works are going on to establish a LNG terminal to import LNG by 2013, which can take advantage of the country's reasonably developed pipeline infrastructure.

Gov. of Bangladesh has initiated preparatory works which are going on to establish a LNG terminal to import LNG from Qatar by 2013.

Moheshkhali has been identified as the possible site for developing the LNG infrastructure.

Around 300 million tonnes of LNG would be imported from Qatar annually to cater to the country's energy need. Qatar has the expertise in developing both long term and short-term LNG infrastructures. The energy officials are now considering some options of the LNG infrastructures, which include a floating storage and de-gasification facility, floating barges with LNG storage facility and on-shore store and de-gasification units. It will take not more than two years to develop such LNG infrastructure; on the other hand it will take 5-6 years to develop the LNG terminal. Moheshkhali has been identified as a possible site for developing the LNG infrastructure on long term and short-term basis. Besides developing the LNG infrastructure, the government is planning to set up a 90 km long gas pipeline from Moheshkhali to Chittagong for transportation of gas.

Different Energy tariffs in Bangladesh are attached in Annex-H.

HFO:

Fuel oil is classified into six classes, numbered 1 through 6, according to its boiling point, composition and purpose. The boiling point, ranging from 175 to 600 °C, and carbon chain length, 9 to 70 atoms, of the fuel increases with fuel oil number. Viscosity also increases with number, and the heaviest oil has to be heated to get it to flow. Price usually decreases as the fuel number increases. Number 5 and Number 6 fuel oil, what remains of the crude oil after gasoline and the distillate fuel oils are extracted through distillation are called residual fuel oils (RFO) or heavy fuel oils (HFO). Power plants and large ships are able to use residual fuel oil.

Annual import of Bangladesh is 38 lakh tons of fuel oil, of which 12 lakh tons is crude oil.

On December 2009, tenders were received by the Power Development Board (PDB) for installation of 10 public sector power plants having a total capacity of 830 MW of electricity. Out of these, only the 200 MW Ghorasal plant will be dual-fuel (gas or diesel) gas-turbine plant, while the remaining 9 will be HFO plants, capable of producing 630 MW of electricity.

The annual import of Bangladesh is 3.8 Mio tons (38 lakh tons) of fuel oil, of which 1.2 Mio tons (12 lakh tons) is crude oil. The Bangladesh Petroleum Corporation (BPC) would need to import 180'000 tons (1.8 lakh tons) of furnace oil in addition. Inside the country Eastern Refinery Limited (ERL) produces around 250'000 to 300'000 tons (2.5-3 lakh tons) of furnace oil annually.

Inside the country ERL produces around 2.5-3 lakh tonnes of furnace oil annually. ERL will install 77-kilometer long submarine pipelines for straight supply of imported crude oils from the Bay to the refinery depots in Chittagong.

ERL will install altogether 77 km of submarine pipelines for straight supply of imported crude oils from the Bay to the refinery depots in Chittagong. The pipelines would have a route of 61 km under the sea from the southwest of coastal Island Kutubdia to Parky Beach of Anwara in Chittagong and from there it will finally be linked to ERL oil depots.

It is evident that the government of Bangladesh reckoned HFO as a good alternative fuel source to meet the current energy crisis in the upcoming years and uses the Bay of Bengal and the Karnafuli river for transportation of the imported HFO. KEPZ, being situated very near to the Karnafuli river, has an advantageous stand in this regard. If KEPZ can provide jetty facilities with good unloading capacity in its premises,

HFO would be a viable option for KEPZ, only if it can provide jetty facility with good unloading capacity in its premises.

the transportation cost of HFO for KEPZ will be very minimal. Otherwise transportation cost of HFO would be quite significant, which will in turn increase the cost of generation per kWh from HFO.

Estimated Cost of Generation at various Fuel Options

The cost of generation with various fuel options based on tariffs offered by other producers have been charted and hereby made available for reference. The prices are indicative and may vary in real case depending on the nature of generation, fuel pricing and availability and technology. The table for cost of generation from the conventional fuel is attached in the following table.

Table 9: Cost of generation from the conventional fuel (in US cents)

Sl. No.	Fuel Used	Cost of power generation/Tariff (Cents/kWh)	Reference
1	Natural Gas (large Scale)	2.75~3	Based on the tariff quoted by the Largest IPP of the Country (Haripur and Meghnaghat, Pendaker Energy Sdn Bhd)
2	Natural Gas (small to medium scale reciprocating engine)	3.50~3.65	Based on the tariff quoted by Small Power Producer under Small Power Policy (Summit, Malancha, Doreen Power etc.)
3	Diesel (Rental Medium Scale)	25.72	Based on the rate quoted by the Rental Power Producer Like Hosaf Energy, Rahimafrooz etc.
4	HFO	20	Based on the rate quoted by the Rental Power Producer Like Hosaf Energy, Cosmos Power
5	Coal Large Scale on Local Coal	4.27	Barapukuria Coal Mining Company Ltd. (BCMCL)
6	Coal Large Scale on Imported Coal	7~7.5	Depending on the nature of the technology and the quality of the imported coal.
7	LNG	10.72	Petronet LNG Ltd, India

In this regard the team of Mr. Yameen worked out on the techno-financial offers collected from the different recognized suppliers regarding power generation alternatives. In this analysis, fuel combinations associated with different mode of power generation for a capacity of 10 MW has been considered. Find the "Preliminary Cost Estimation and Technical Requirement Estimation of a 10 MW Power Plant for an Industry"; placed in Annex- I.

Conclusions

The present energy demand viz a viz the gas demand forecast reveals that indigenous natural gas would be in short supply from the year 2015 and by the year 2025 gas short supply would rise to 8.35 tcf. The need to find out gas reserve cannot be undermined and it is equally important that other energy sources (like coal) that are available in the country can be utilized in order to undertake greater share in the total energy mix of the country. It is therefore evident that actions must be initiated immediately for developing the coal deposits of the country in order to ensure that coal in adequate quantity is available for power generation before 2015 as alternative commercial energy fuel.

It is important for KEPZ to consider other commercial fuels than NG due to its current supply shortage. HFO has been allowed by Government for private power generation and is cheaper compared to diesel, KEPZ may seriously consider HFO for power generation in next phase of development until the availability of coal and natural gas is ensured

From the analysis on different fuels we see, although coal comes out as one of the cheapest alternative but this sector would take a long time to develop and huge political intervention will also be required for its commercial availability. In addition to this, gas exploration has to be accelerated to catch the pace of energy demand of the country. Moreover, government tendering to award gas blocks to private sector also needs to be completed on a fast track manner. Now it is important for KEPZ to consider and avail commercially available and competitive fuel sources to pass this transition stage. As HFO has been allowed by the government to be used for private power generation and if we compare it to costlier diesel power, KEPZ may seriously consider the HFO option and implement one or two HFO power generating units in their next phase of development until the country is going to have significant availability of coal and natural gas. In this case, it is also important to account CO_2 emissions from coal based power generation, as it might make the usage of coal much more expensive in terms of emissions and also affect the impression of developing a green economic zone burning less pollutant fuels.

6. Energy efficiency considerations regarding industrial production

6.1 Introduction

To point out, which energy efficiency measures will be crucial for KEPZ, an existing shoe production facility of Youngone in CEPZ has been analysed.

- The first step of determining energy efficiency potentials was to analyse the production process and find weaknesses
- The second step involved the finding of solutions. Two major groups of improvements could be defined
- In the third and last step, the findings have been adapted to the situation at KEPZ, so that they can be taken into consideration during the planning phase. By planning the site accordingly, the factories that are in construction now are optimized to run as efficient as possible

Due to the fact that the energy efficiency potentials are very high if applied properly, a separate study about energy efficiency measures in CEPZ and KEPZ is in the making and will be finished by September 2011.

6.2 Shoe production process

6.2.1 Technical overview

A shoe consists of three layers of sole and an upper part. While the soles are processed from raw material in an energy intensive operation, the upper shoe is a more labour intensive process, requiring cutting and sewing of synthetic leather or fabrics. In the final stage the formed and set upper shoe is glued with the soles and dried. Among the soles, the insole is the least energy consuming. The rubber outsole and EVA insole start their journey from the same machines in the production floor namely kneading and mixing rollers. Later, these are passed through calendars and hot presses. Soles of uniform density are then cut to size. Upper shoes are cut in cam cutters and sewn together. Then comes the three dimensional forming

Production of shoe consists of 3 layers of sole and 1 upper. Soles processing is the most energy intensive part while processing the upper is labour intensive.

part. For this, the upper shoe is laid over a dummy foot with a thin fabric on the sole and heat set[22] in IR heaters. The indexed and formed upper shoe is then glued together with the sole, dried and heat set by an army of workers in an assembly line. The brief on production process is shown in the figure below.

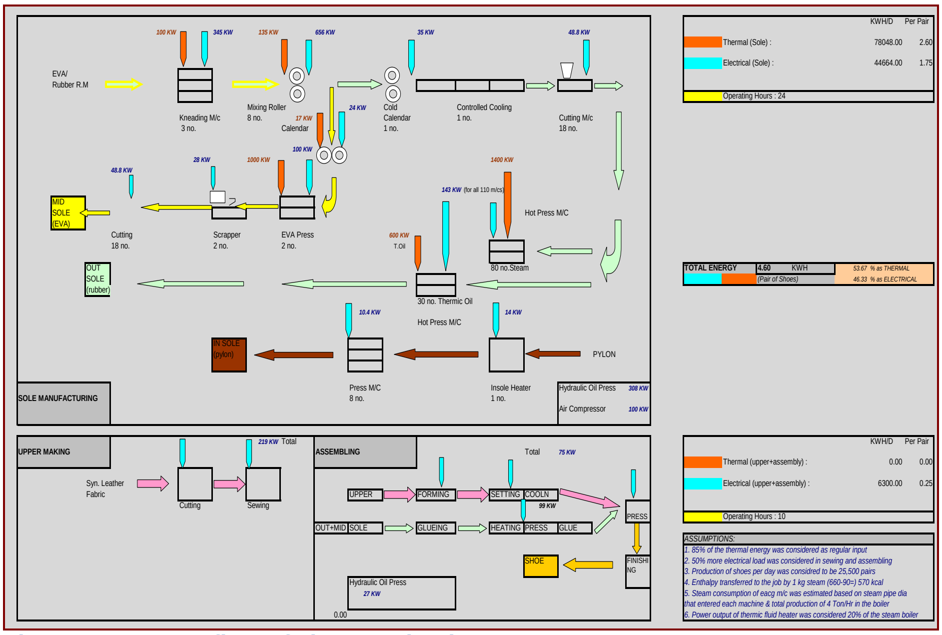

Figure 15: Energy flow of shoe production

The total energy requirement of YO Shoes per pair is 4.6 kWh ($2kWh_{el}$ & 2.6 kWh_{th}). Hence, 53.67% of the required energy is thermal and the rest is electrical.

6.2.2 Electrical and thermal energy requirement

Shoe production is energy intensive, consuming around 4.6 kWh ($2kWh_{el}$ & 2.6 kWh_{th}) per pair of shoes. The most energy intensive production process is that of out- and midsole.

Currently, the steam is provided with a 5t/hour gas boiler. If waste heat recovery boilers are installed, the overall efficiency of the generators can be raised by 30%, using their waste heat to provide a part of the steam demand.

The total annual energy demand is estimated to be 85'000 MWh_{el} and 99'000 MWh_{th} for producing 4 million pairs of shoes.

For more technical details please refer to Annex-J.

[22] Heat setting is a term used in the textile industry to describe a thermal process taking place mostly in either a steam atmosphere or a dry heat environment. The effect of the process gives fibers, yarns or fabric dimensional stability

6.3 Probable energy efficiency measures for KEPZ shoes

6.3.1 Actual situation at KEPZ

The “KEPZ shoe production” is placed on an area with a total of 370’000m^2. The 16 shoe factories with four production lines will have a yearly output of around 4 million pairs of shoes. The project was supposed to start at the end of November 2010 with 4 factories and a total of 6000 workers. Besides the factories, there are also two dining halls, one administration office and some custom related facilities. Additionally, 40-50 houses will be built for the workers. After the completion of the “KEPZ shoe production”, more than 30’000 workers will be employed.

The four production buildings which are being built first at KEPZ will acquire their electrical energy demand from the public electricity grid. Due to instabilities of this grid, 3 standby diesel generators will be installed, each with a power output of 1.5 MWel. Steam will be generated in a boiler, probably run with coal. The following figure shows the situation plan at KEPZ with the place of the factories.

One shoe factory (around 80'000 m3) consists of 4 production lines with a yearly output of around 4 million pair of shoes. Start of the project was initially by of November 2010 with 4 factories to start operations. Besides the factories the „KEPZ shoe production"-complex consists of two cantinas, one administration office incl. financial / logistical services and some custom related facilities. In parallel, more than 40-50 housing facilities will be built in the western part of the industrial plot for the workers.

The effluent treatment plant and other environmental protective measures are under preparation as defined in the recently approved „Environment Management Plan". "KEPZ shoe production" will be compliant to all existing EHS-standards in the country, giving employment to more than 30'000 workers after completion.

Figure 16: Factories at KEPZ

6.3.2 Energy efficiency measures

Energy reductions can be achieved through several measures. For a better overview, they are separated into three different main categories:

- Simple process improvements
- Efficiency of Buildings
- Co-Generation

6.3.3 Reducing energy demand through simple process improvements

The aim should be a general philosophy of reduction. Processes are to be designed for a minimal usage of electricity, heat and compressed air and steam. By using machineries with smarter controls, more efficient motors, better hydraulics and a lighting system based on energy saving lamps or LED, these goals can be achieved.

Through a multi layered pareto-analysis and a systematic root cause analysis, the whole manufacturing cycle can be optimized to reduce the rework rate and the percentage of off-grade products.

The steam-cycle can be optimized in several aspects. These include the operating pressures, condensate return systems, economizers and pre-heaters in boilers. Also, repairing leaks and improving the insulation in water & air pipes can avoid energy losses. Gen sets are to be operated on a lean setting of the air to fuel ratio to ensure highest efficiency. Running the generators at the highest optimum load will ensure the most economical usage of fuels.

6.3.4 Modern Energy Efficient Buildings

In this case modern energy efficient buildings mean to construct buildings on the highest, in Bangladesh available, technical standard under consideration of the environment.

There is scope for emission reduction of greenhouse gases (GHG) by incorporating energy efficient and ‘Green’ designs for processing and non-processing buildings at KEPZ. With this modern energy efficient measures a reduction of up to 30% of the total energy requirement of each building can be achieved. Such measures are eligible for under CDMs for Carbon Credits which is further elaborated in chapter 9.1.3.

The government is going to approve the draft Energy Conservation Act 2010 soon, where a lot of financial and other regulatory incentives are to be considered to encourage these clean environment friendly initiatives.

6.3.5 Co-Generation

A significant reduction in energy primary demand can be achieved, if any economic zone is constructed with the provision of central power and heat generation facility, commonly known as co-generation. Conventional power plants generate electricity only and release a large part of the used primary energy in the form of heat into the atmosphere. Co-generation plants, on the other side, recover the exhaust heat of the power generating units and use it to produce steam with the help of waste heat recovery boilers. This method can enhance the overall efficiency of the power generation systems to even 85% as opposed to about 30~35% efficiency of conventional power plants. Steam generated from such a captive power plant can be supplied to the nearby industries to meet their heating application through a mutually agreed tariff from a central location.

In single factories like the shoe factory, co-generation is also possible. The heat in the exhaust gas (which is at about 450-550°C) can be used to run a waste heat recovery boiler (WHRB). These boilers can raise the overall efficiency of the electricity generating process from 30% to about 50-70%, depending on the generator and boiler type. Heat on lower temperature levels (jacket/cooling water) can be used to run a refrigeration cycle, which can run an air-conditioning system in the factory.

The potentials of co-generation are explained more deeply in the additional study on energy efficiency.

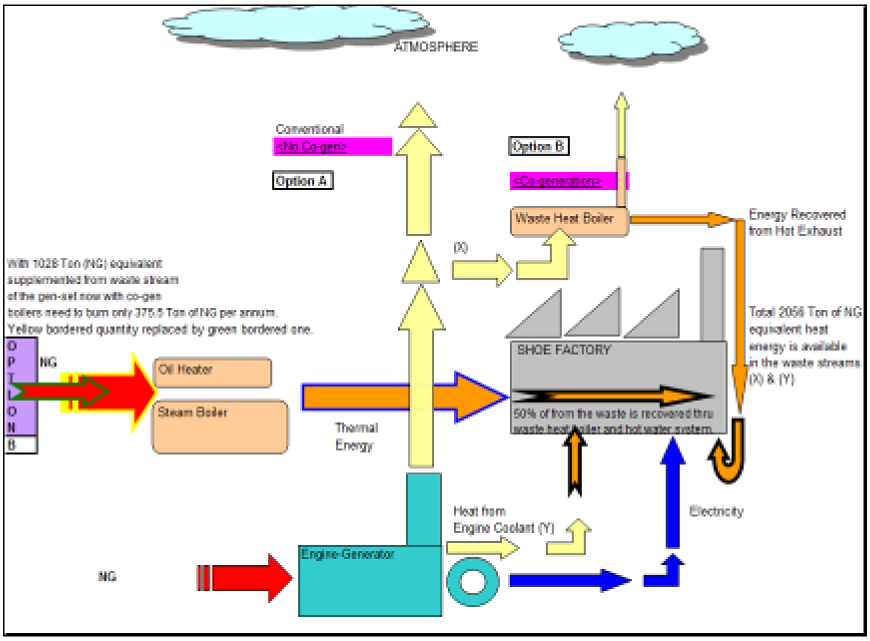

Figure 17: Schematic Co-generation Plant of Shoe Production unit.

6.4 Conclusions

All the identified potentials to reduce the energy consumption in the shoe manufacturing process are well proven in terms of technology and can be implemented with limited investment. KEPZ authority can prioritize the recommended measures for improving energy efficiency in the new plant in respect to the CEPZ shoe production unit. In this way, a good example of a modern energy efficient shoe production facility can be set. The main conclusions regarding energy efficiency are:

- The production process itself is already well optimized to run at a high efficiency (based on the CEPZ shoe production). On the other hand, the energy supplying facilities were not well optimized yet. Though unused steam was returned to an economizer for the boilers to heat up the inlet water, the generators and boilers were running on their own, without benefiting from each other.
- The usage of co-generation has a very high potential. By recovering the waste heat of the generators, a significant part of the thermal energy demand can be provided. A following study, which will be published in September 2011, will provide more information on this subject.
- The total annual energy demand for the processing and non-processing buildings could be reduced by about 30% with modern energy efficient buildings.
- Different simple process improvements such as better insulation, economizers, repairing leaks, etc. could also be an important part for an efficient industrialisation.
- If energy efficiency measures are taken into account during the planning phase of sites or facilities, further costs in the future can be avoided. This includes intelligent placement of generators and boilers, short pipe lines, etc.
- The energy demand could be **reduced by about 30%** through better efficiency.

7. Hybrid Grid at KEPZ

7.1 Introduction

Hybrid grids supply island networks that are not connected to an integrated grid such as a regional or national grid. Hybrid grids have several electricity generating components. Renewable energy sources like wind turbines, photovoltaic, solar thermal, hydro power, wave power or biomass power stations, and fossil power plants like diesel generators, gas turbines or fuel cells etc. can be integrated in a hybrid grid. A major control system is required to run the grid. The special requirement for hybrid grids is to match demand and supply in the long term and instantaneously for stable grid operation. On the demand side, base load is needed continuously 24 hours per day, medium load is required in 3 to 6 consecutive hours, and peak load is required in shorter sequences, sometimes only for seconds. There can also be seasonal fluctuations. However, supply from renewable energies follows seasonal, daily variations and random patterns. Therefore the fluctuating consumption pattern requires specific features:

- Hybrid power systems have to cope with much more severe short term variations in power demand
- Special energy management structures are needed which vary with the size of the hybrid power system

Depending on the size of the grid, various options are available for the equalization of load variations. Hundreds of kW can be provided by compressed air and several kW by batteries. In situations where there is no storage it is replaced by a dynamically controlled generator driven by a fuel engine or a hydropower turbine. As the option for a hydropower turbine has already been excluded, load variations could be handled by a gas turbine or diesel generators. Both are able to increase or reduce their power output within seconds. In small systems different options are available for frequency and voltage stabilization:

- In small systems up to 50 kW, inverters and battery systems are applied for frequency and voltage stabilization

- Larger systems depend on continuously running synchronous generators with controllable engines; water turbines can be equipped with flywheels.

A diagram of a typical hybrid grid is placed in Annex-K.

7.2 Potential of a hybrid grid at KEPZ

The situation at KEPZ is somewhat unusual because the total power demand will by far exceed what is possibly available from renewable resources. In such a situation the site either has to be grid connected or there has to be one large synchronous generator which is driven by a non-renewable resource that is used to control the hybrid grid.

The total electricity demand of approximately 250 MW will not be needed instantaneously but following the industrial development within KEPZ over a period of some 10 years. The potentials for electricity generation from renewable sources are rather small, not exceeding a few MW. Therefore, out of the total demand of 200–250 MW only a small portion of electricity can be provided by renewable resources. The hybrid grid would therefore have a large non-renewable power plant (PP), such as a gas turbine power station, which would be controlling the KEPZ grid.

This “hybrid grid” option has two important consequences for KEPZ:

1. The flexibility to balance load and generation (demand and supply) must be provided by the KEPZ owned power plant which means that this power plant would frequently operate under unfavourable partial load conditions and that it would have to be overdesigned in terms of installed capacity.

2. It would also mean that the installed capacity somewhat has to follow the increasing demand as resulting from the industrial development of KEPZ. Both these conditions are very unfavourable for an efficient and economic operation. The advantage of such a “hybrid grid” solution would be that KEPZ can operate independently from the public grid.

The other option is to rely on the public grid. There is also the possibility of a mixture where some of the load is covered by a KEPZ owned PP and some from the public grid. Because of the above mentioned disadvantages it is likely that such a mixed grid connected solution would be the most economic one. Such a solution could be designed in such a way that it could be operated as an "emergency" hybrid grid in situations where the public grid fails or is unavailable. Such a solution would also offer the possibility to sell excess electricity from the KEPZ PP to the public grid during the early development stages of KEPZ, when only a smaller proportion of the electricity produced is consumed by KEPZ industries. Later, as KEPZ industries and their demand grow, a larger portion of the electricity generated within KEPZ will be self-consumed. The time of installation, installed capacity and how the load will be balanced will depend on:

- Generation costs in KEPZ PP
- Tariffs for electricity sold from KEPZ PP to the public grid
- Tariffs for electricity bought from the public grid
- Availability and contractual agreements for electricity purchases from the public grid
- Load management within KEPZ (what is the maximum capacity which must be available and what would be a minimum "emergency" load

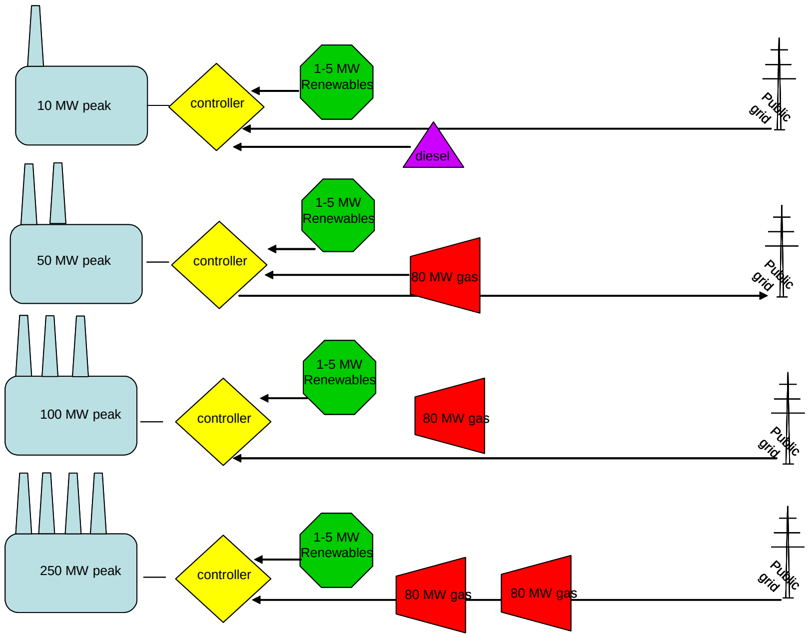

Figure 18: Possible hybrid grid solutions for KEPZ

For fast load balancing a gas turbine is the only option, as it can follow load fluctuations within seconds. If load balancing can be provided by the public grid, a (much slower) coal power plant would also be an option.

8. CDM and KEPZ

Clean Development Mechanisms (CDM) are among the defined flexibility mechanisms in the Kyoto protocol. It allows Annex-B countries to reduce their greenhouse gases in Non Annex-B countries (developing countries). The Annex-B countries receive Certified Emission Reductions (CER) for projects in Non Annex-B countries; one CER is equal to one ton of carbon dioxide equivalent. Figure 19 illustrates how the CDM mechanism works.

Clean Development Mechanisms (CDM) as a chance for non Annex-B countries, such as Bangladesh.

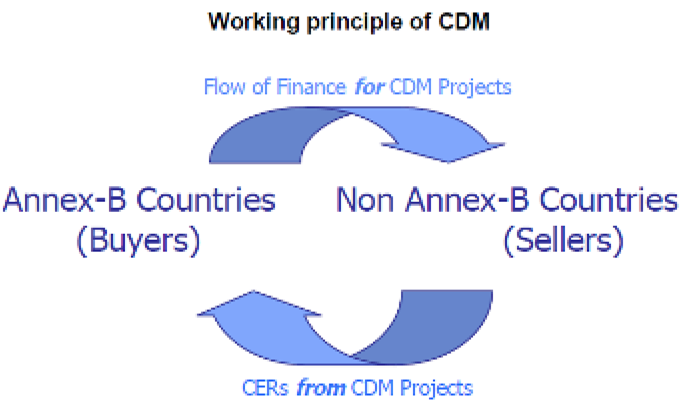

Figure 19: Working principle of CDM

Estimations shows that CDM could bring revenues up to 20-30 M USD from the different environment friendly development initiatives

The following general arrangements are identified for KEPZ, where potential CDM projects can be developed:

8.1 Energy efficiency improvement through CHP

A significant gain in energy reduction can be achieved if energy intensive industries are operated using their own power generation systems that generate power and heat together, commonly known as CHP (combined heat and power generation). Unlike conventional thermal power plants, this method can enhance the overall efficiency of the power generation systems up to 89% as opposed to about 30~35% efficiency of conventional thermal power plants.

8.2 Waste energy recovery

A few examples of applying waste heat recovery units are as follows:

- The temperature of exhaust gases can be utilized to pre-heat the inlet fluid of industrial boilers thus decreasing the thermal energy intake of the fluid.
- Exhaust gases can be run through heat pipe exchangers for air heating.
- Waste heat from furnaces and kilns of industries such as ceramic industry can be used in other industrial heating applications.
- Temperature of condensates from dying machines in a garment industry may be utilized to pre-heat other fluids that are used in other processes of the same industry.

8.3 CDM Scope for Renewable Energy Technology (RET)

Considering the acute power crisis, the time has come for the industrial owners to adopt RET in their industrial planning process. CDM under the Kyoto Protocol is an instrument for financing low carbon development in newly industrializing and developing countries. In this situation, KEPZ is rightly planning to consider renewable energy sources to meet certain parts of their total power requirement.

In addition to this, RET implementation can reduce increasing dependence on fossil fuels. KEPZ acknowledges the importance of RET for its energy security and has voiced targets: a 20% share of the total installed electricity generation capacity is supposed to be incorporated by RET. The installation of solar, biomass and hydro technologies for the supply of power and heat in KEPZ factories will be able to substitute a significant portion of the conventional contribution of fossil fuels like natural gas, diesel and furnace oil. As an added benefit, this technology does not emit any carbon to the atmosphere. For this, KEPZ will be able to cut a fair amount of carbon emission and be eligible to claim for carbon credits through CDM.

The exploitation of RET has a great potential for climate protection. Financial investment in CDM associated with adequate national policies could greatly advance RET towards the stage of commercialization. We are, in this respect, in a better position, as the Bangladesh government has already developed the “Renewable Energy Policy of Bangladesh” in 2008.

8.4 CDM scope for Energy Efficient Building Designing

There is a scope for emission reduction of greenhouse gases (GHG) by incorporating energy efficient and ‘Green’ design for Processing and Non- processing buildings at KEPZ.

Energy efficient building design based on sustainable and environment-friendly architectural concepts results in environmental protection, water conservation, energy efficiency, usage of recycled products and renewable energy. An Integrated Building Management System (IBMS) will manage the Heating Ventilation and Air-Conditioning system (HVAC), lighting, power, individual access control, vehicle access control, parking, fire detection & control, lifts, water & waste disposal management, office automation processes and communication processes in the building.

The major energy efficiency measures that can be taken are:

- Reducing the lighting load by improving the natural lighting and energy efficient luminaries.
- Designing the building direction in such a way so that natural light and air can be utilized at its maximum.
- Installation of solar photovoltaic systems for power production in the buildings can reduce the dependence on the grid power.
- Waste heat can be used for HVAC which reduces the energy consumption of HVACs.
- Ensuring Roof / Wall insulation to reduce load on HVAC.
- Using certified wood & high-performance glass.
- Air-side economizers can save energy in buildings by using cool outside air as a means of cooling the indoor space.

- Ensure water use reduction by recycling of water and rain water harvesting.
- Improved water & waste disposal management
- Improved vehicle access control, parking, fire detection & control, lifts, office automation processes and communication processes

With this modern energy efficient measures a reduction up to 30% of the total energy requirement of each building can be achieved. It also helps reducing GHG emission which is caused by that 30% extra energy consumption. This energy reduction can contribute in generating carbon credits of significant amount if a majority of the buildings in the non-processing and processing areas are designed in this way. So, KEPZ may consider these measures in the architectural design of those buildings and ensure CDM benefit out of it.

8.5 Total CDM potential for KEPZ

A combined savings of about 40 MWh_e on total electrical power consumption and 60 MWh_{th} on heat application through energy efficiency, process improvement, adoption of RET and energy efficient building design can be achieved. If this is converted to CDM projects for a period of 10 years, the total accumulated CERs from these two sectors will be approximately:

- From Power = 914’500 CER
- From Heat application = 1’371’810 CER
- Total = 2’286’360 CER
- Revenue = 12 USD/CER
- Total Revenue = 27.5 Million USD[23]

This total amount or individual shares of it can be included in the life time cost analysis of various components of the KEPZ development.

[23] This calculation is a first rough estimate by Rahimafrooz (Bangladesh) and should show the possibilities of CDM. However, for a more specific project the number of CER’s should be evaluated again.

9. Recommendations for KEPZ

The energy situation in Bangladesh is in a total crisis and KEPZ should not depend on a solution of this crisis provided by the government. The opportunities of using renewable energy to supply KEPZ with electricity and heat appear to be quite limited for several reasons:

1. The demand for electricity and process heat is very concentrated in this industrial zone. It is therefore obvious that it will be difficult to cover this demand to a large extent as long as the area available for renewable energy harvesting is limited to KEPZ.

2. The heavy subsidies for fossil primary energy are deteriorating the market and prevent a faster breakthrough of renewable energies. But of it is questionable how long these subsidies will remain in place; so a prudent investor will take this uncertainty into consideration.

As the government is opening up the energy market to private power producers (see chapter 3.4) by allowing various mechanisms of selling electricity in an open market it is strongly recommended that Youngone takes on a much stronger proactive position and starts acting as an **independent power producer** immediately, first of all for its own purposes and the expanding KEPZ zone and secondly to sell whatever is left into the public grid as a buffer. KEPZ may enter into any such open access contract with the transmission operator (PGCB) to sell their generated power through the national grid by paying wheeling[24] charges determined by the government. The contractual

[24] See act of transporting electric power (megawatts or megavolt-amperes) over transmission lines or the act of providing the service of transporting electric power over transmission lines.

arrangement for such power selling is shown below:

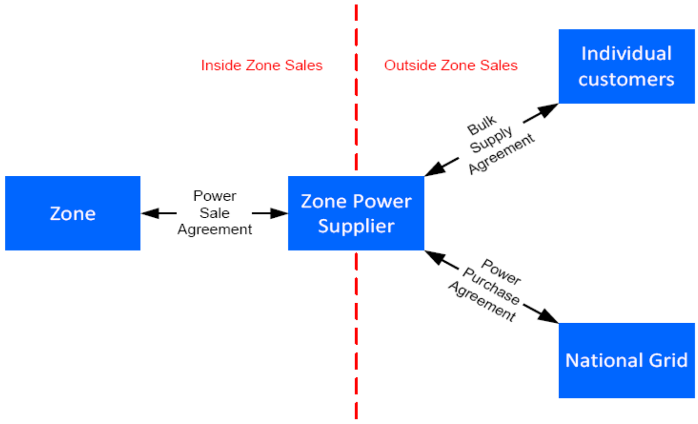

Figure 20: Contractual framework for power sales from

Youngone has the land, access to waterways and therefore to carriers of primary energy, guaranteed buyers (their own factories), financial capacities and most likely governmental support. That is a very good position to act successfully in this extremely stressed energy market.

The general idea would be to do everything in order to **reduce the overall energy consumption by 30% by applying all measures** suggested in this report:

- All industries wishing to establish themselves within KEPZ must follow **highest industrial standards regarding energy conservation**. The selection and stepwise growth of industries must be in conjunction with the energy which can be provided[25].

- KEPZ must establish its own **hybrid grid with a strict focus on co-generation** where electricity and process heat is generated by KEPZ power plants at efficiencies of more than 85% (fuel source will be fossils).

- In terms of **load balancing** the most expensive electricity is peak demand, which needs to be provided for but is hardly ever used. An important factor in the economy of the whole setup is therefore load management. The purpose would be to reduce load peaks

[25] Combinations of industries are established which have a need for both types of energy, electricity and heat, both will be provided by one or several central KEPZ plants. This will greatly increase the economic feasibility.

drastically and therefore to reduce the necessary installed capacity[26].

If load management strategies like this are applied consequently and they required peak load can be reduced therefore, the share of renewable energies could be significantly increased in terms of capacity, not so in forms of production. However, a reduction in required installed capacity provides very significant cost savings.

At the same time all options for the **utilization of renewable energies** should be implemented. Some of the most prominent options on renewable energies include:

- Grid connected photovoltaic panels on roof tops of each industrial and other residential and commercial building.
- Solar Water heater for non-processing requirements.
- With ensuring external supply of waste bio-mass, KEPZ can implement a bio-mass based power and heat generation unit.

With this kind of initiatives KEPZ feeds the hybrid grid and also serving with “best practices” renewable projects for the rest of the country and other industrial zones. This may only be five or 10% of the overall electricity needed for KEPZ but as long as these plants can be run economically viable it should be done. The operators could be independent units within KEPZ or even private entrepreneurs.

The final result would be a highly efficient KEPZ owned hybrid grid based on co-generation from some fossil fuel and a small proportion of renewable energies. Whatever is consumed within KEPZ will remain there and the small rest will be sold to the public grid. The growth of this power generation system will somehow have to go along with the growth of the KEPZ industrial development, with the public grid acting as a buffer for electricity generated but not consumed within KEPZ at times when the stepwise industrial

[26] For this purpose smart grids within the KEPZ might be considered. Smart grids are operating both ways, sending electricity and signals in both directions. Since the starting current of a machine can be as much as 10 times the rated current is fundamentally important that certain types of machines do not start operating at the same time. For example, a smart grid could switch off a number of coolers or air conditioners, which are running permanently, for a few seconds, to make the starting current for some kind of machine available without increasing the peak load.

development is lagging behind the development of the energy system. This strategy would reduce the problems caused by the phase wise development.

KEPZ must establish its own unit where all possibilities of CDM[27] and selling carbon credits are consequently utilized to help financing not only electricity, steam and heat generation, but also production, factories, housing etc. All industries and their designers must coordinate their activities with this unit.

[27] CDM is only one possibility of many others to promote renewable energies and energy efficiency. There are also other mechanisms like the Green Climate Fund or soft loans of the World Bank or other multination development bank (for example, the Asian Development Fund).

10. Key findings for a sustainable (energy) industrialisation in Bangladesh

The demographic and economic development of Bangladesh will lead to a further increase of demand for energy. At the moment there is no real hope that the infrastructural development of Bangladesh will be able to keep up with the increased future energy demand. This leads to the conclusion that the actual scarcity of energy will be the most realistic scenario in Bangladesh. Hence for a sustainable industrialization in Bangladesh good energy (efficiency) solutions are needed today and tomorrow.

The REPIC-study pin-points that, empirically based on KEPZ and its future energy demand, there are some ideas and concrete measures which may lead to a more sustainable (energy) industrialization in Bangladesh. These are listed below.

- Future industrial/economic zones in Bangladesh must protect the natural biodiversity as good as possible by creating artificial water bodies, planting trees etc. As in the case of KEPZ, a good equilibrium has to be defined among industrial/commercial and non-industrial zones. As a "green industrial zone," about 50% of the land of KEPZ is kept green.

- The industry-mix within a zone is a vital ingredient for a sustainable industrialization. As shown in KEPZ, the planning/design of the grid and its load-management is highly depending on the existing industries and their production efficiency. An intelligent phase-wise development of an industrial zone is very important. To start an industrial/economic zone in areas where energy crisis persists, the zone planner should start with light industries that consumes less energy and develop the zone in phases. This helps to assure a continuous improvement of the hybrid-grid and ultimately the entire zone.

- To endorse a sustainable industrialization in an industrial / commercial zone, the energy-mix might include an essential part of renewable energies (as a "working thesis"). To reach this goal it is important to go step by step. The first part could be the illuminating of the factories by solar energy. Adequate incentives might guarantee the use of renewable energies from the very first planning of the zone. A concept of “hybrid grid” will help to integrate renewable energy sources with the existing conventional sources. Adjacent to solar, biomass and hydro the hybrid grid might also include wind solutions, a still undiscovered potential especially in the coastal areas of Bangladesh.

- For existing zones the focus remains on forceful improvement of energy efficiency. As shown in KEPZ/CEPZ shoe production, this may include inception of combined cycle, co-generation facilities, waste heat recovery, process improvement and other energy efficiency measures.

- Especially the subject “waste heat recovery” and “co-generation” can save about 30% of the total energy input of the boilers. A separate study about energy efficiency measures at CEPZ and KEPZ will show this coherence and will be finished and published by September 2011.

- For a sustainable industrialisation in Bangladesh and especially at KEPZ it is also important to know the flow of materials and energy. This will be the groundwork of an efficient resource management.

- In a developing country with quite a small economy like Bangladesh, conservation of energy is always a wise and smart option right away. Conservation generally saves a huge amount of energy. Therefore it is suggested that the zone planner should go forward implementing projects with the option of conservation of energy from the very beginning.

- It is important to consider, that investments in renewable energies and sustainability in general will only break-even after 5-20 years. All these initiatives towards a more sustainable industrialization might be cushioned by the carbon revenue earning potential by the Clean Development Mechanisms.

Finally it is noteworthy that price of the conventional energies in Bangladesh is highly subsidised and hence are very cheap. As long as energy prices are highly subsidised in Bangladesh, the use of renewable energies is still not a cost effective option. The international discussion to stop the subsidisation of fossil fuels has started in 2009 by G-20; their goals might be a chance for Bangladesh to change their subsidisation policy.

Table of references

The following main working papers were elaborated during the KEPZ-feasibility study. The below mentioned working papers are the basis for the final report, but they are for internal use only:

Project partner	Title of working paper
Rahimafrooz Renewable energy Ltd. (= RREL / diverse Autoren)	1. Energy and Power Situation of Chittagong Region
	2. KEPZ Baseline Analysis on Power Requirement
	3. Solar Test Application at KEPZ

Project Partner	Title of working paper
ETH (T. Schmidt/M. Peters)	4. Cost and potential of solar thermal energy at KEPZ
Entec AG (K. Jorde)	5. Hydropower, groundwater and “hybrid-grids”
Holinger AG (P. Jeitz)	6. Renewable energy from biomass for KEPZ

Additionaly, the following important interim reports have been done:

Project Partners	Title of working paper
Youngone Ltd. (div. Autoren)	7. Energy requirements for shoe production at YSA/YSS
RREL (diverse Autoren)	8. Price and Tariff of Energy in Bangladesh
RREL (diverse Autoren)	9. Comparative analysis on conventional fuels for KEPZ
Holinger AG (O. Deiss)	10. Cleaner Production – situation analysis
RREL (diverse Autoren)	11. CDM opportunities for KEPZ (brainstorming)

Other important sources:

Cleaner Production report

1. http://ec.europa.eu/environment/ecolabel/ecolabelled_products/categories/footwear_en.htm
2. UNIDO leather and leather production industry panel 2000
3. Adidas environmental report 2008
4. NIKE, Inc. Corporate responsibility report 07/08/09

Energy and Power Situation of Chittagong Region

5. Chakma, E. S. (2010, March 16). Chief Engineer, Bangladesh Power Distribution Board, Chittagong, Distribution Southern Zone. (S. A. Nazib, Interviewer)

6. Chanda, A. (2010, March 16). Assistant Engineer , Bakhrabad Gas Systems Limited . (S. A. Nazib, Interviewer)

7. Chittagong Power Development Board. (2010). Power Demand,generation and load shedding report of Chittagong region. Chittagong: CPDB.

8. Piotr D. Moncarz, P. A. (2007). Bangladesh Gas Sector Issues, Options, and the Way Forward. Philippines: Asian Development Bank.

9. Bangladesh Power Development Board. (2010). Summary of Daily Generation. Dhaka: Bangladesh Power Development Board.

10. Gas Transmission Company Limited. (2009). GTCL. Retrieved March 25, 2010, from GTCL: http://www.gtcl.org.bd/trans oper.php

11. Petrobangla. (2010). Daily Gas & Condensate Production and Distribution Report. Dhaka: Petrobangla.

12. Power Grid Company of Bangladesh. (2010). Central Load Despatch Center, Peak Hour Demands Of Different Areas. Dhaka: Power Grid Company of Bangladesh.

13. Power Grid Company of Bangladesh. (2010). Description of the generation of various power stations. Dhaka: Power Grid Company of Bangladesh.

14. Rahman, M. A. (2010, February 13). Drastic Fall in Sangu gas output. The Financial Express

15. Amin, N. (2009, May 22). Bangladesh:Cairn Installing Gas Compressor to Extend Sangu's Life. Retrieved March 27, 2010, from energy bangla: http://www.energybangla.com/index.php?mod=article&cat=GasSector&article=1846

16. Bangladesh Power Development Board. (n.d.). http://www.bpdb.gov.bd/generation/htm. Retrieved March 25, 2010, from Bangladesh Power Development Board: http://www.bpdb.gov.bd

17. Other Web Sources:

    http://countrystudies.us/bangladesh/

    http://www.indexmundi.com/bangladesh/

    U.S. Library of Congress

    CIA World Fact book

    http://bangladesheconomy.wordpress.com/

    Asian Development Bank http://pid.adb.org/

    Action Aid Bangladesh http://www.actionaid.org/bangladesh/

Center for Policy Dialogue: Population and Sustainable Development

Bangladesh Experts http://www.bd-experts.com/

KEPZ Baseline Analysis on Power Requirement

18. Bangladesh Private Sector Development Support Project-Economic Zones Development Assignment, DFID & World Bank, Final Base line Report on Infrastructure Demand Assessment for Comilla Expansion Project, Kalia-koir high-tech Park, Meghna EPZ (proposed) and Narsingdi EPZ (proposed)s
19. Bangladesh Private Sector Development Support Project-Economic Zones Development Assignment, DFID & World Bank, Final Base line Report on Infrastructure Demand Assessment for Comilla Expansion Project, Kalia-koir high-tech Park, Meghna EPZ (proposed) and Narsingdi EPZ (proposed)s
20. PSDSP Economic zone development report

Solar Thermal Energy

21. SusTec Linear Fresnel cost model, Technology Innovation Report CSP (2008)
22. Kalt Schmitt, KEPZ team, NLWKN, Swera
23. Bischofberger, Kalt Schmitt, KEPZ team, SWERA
24. Energy Plusweather data, SusTec LCOE model

Biomass

25. www.idcol.org
26. Twelfth European Biomass Conference, Amsterdam 2002
27. www.wastconcern.org
28. www.becon.eu
29. www.strabag.de
30. www.kompogas.ch
31. Fermentation studies, Institute for Recycling and Environmental Protection (IKrW)of the University of Bremen in Germany carried out

Price and Tariff of Energy in Bangladesh

Official website of Bangladesh Bank

Barapukuria Coal Mine Company Ltd.

See Annex H

Comparative Analysis on Different Alternative Conventional Fuels for KEPZ

32. Chakma, E. S. (2010, March 16). Chief Engineer, Bangladesh Power Distribution Board, Chittagong, Distribution Southern Zone. (S. A. Nazib, Interviewer)

33. Chanda, A. (2010, March 16). Assistant Engineer , Bakhrabad Gas Systems Limited . (S. A. Nazib, Interviewer)

34. Chittagong Power Development Board. (2010). Power Demand,generation and load shedding report of Chittagong region. Chittagong: CPDB.

35. Piotr D. Moncarz, P. A. (2007). Bangladesh Gas Sector Issues, Options, and the Way Forward. Philippines: Asian Development Bank.

36. Bangladesh Power Development Board. (2010). Summary of Daily Generation. Dhaka: Bangladesh Power Development Board.

37. Gas Transmission Company Limited. (2009). GTCL. Retrieved March 25, 2010, from GTCL: http://www.gtcl.org.bd/trans oper.php

38. Petrobangla. (2010). Daily Gas & Condensate Production and Distribution Report. Dhaka: Petrobangla.

39. Power Grid Company of Bangladesh. (2010). Central Load Despatch Center, Peak Hour Demands Of Different Areas. Dhaka: Power Grid Company of Bangladesh.

40. Power Grid Company of Bangladesh. (2010). Description of the generation of various power stations. Dhaka: Power Grid Company of Bangladesh.

41. Rahman, M. A. (2010, February 13). Drastic Fall in Sangu gas output. The Financial Express

42. Amin, N. (2009, May 22). Bangladesh:Cairn Installing Gas Compressor to Extend Sangu's Life. Retrieved March 27, 2010, from energy bangla: http://www.energybangla.com/index.php?mod=article&cat=GasSector&article=1846

43. Bangladesh Power Development Board. (n.d.). http://www.bpdb.gov.bd/generation/htm. Retrieved March 25, 2010, from Bangladesh Power Development Board: http://www.bpdb.gov.bd

44. Other Web Sources:
    a. http://countrystudies.us/bangladesh/
    b. http://www.indexmundi.com/bangladesh/
    c. U.S. Library of Congress
    d. CIA World Fact book
    e. http://bangladesheconomy.wordpress.com/
    f. Asian Development Bank http://pid.adb.org/

g. Action Aid Bangladesh http://www.actionaid.org/bangladesh/

h. Center for Policy Dialogue: Population And Sustainable Development

i. Bangladesh Experts http://www.bd-experts.com/

Clean Development Mechanism

45. UNEP Risoe , March 2008

Annexure

A. Area distribution for processing and non-processing area in acres

Category of use	Total areas demarcated (acres)	Total areas demarcated (m^2)	% of the total area
1.Industrial Use(including space for standard factory building)	**1339**	5'418'746	**51.8**
2. Ware House Area	**20**	80'937	**0.7**
3.Jetty & Backup Facilities	**80**	323'749	**3**
4. Zone support Services: (a) Zone administrative offices-3 location (b) Vocational training and language school (c) Dormitory, Conference center and other facilities (d) Hospital (e) Police Post, Fire brigade, Post Office, Custom and Other Offices (f) Commercial area, exhibition hall and convention center	11 10 10 5 8 20	44'515 40'469 40'469 20'234 32'375 80'937	**2.5**
Total	**64**	258'999	
5.Utility Services Area: (a) Electricity generation & sub-station-5 locations (b) 33/11KV transmission line-15km (c) Deep tube wells and pumping stations including approach roads-30 locations	7 18 18 3	28'328 72'843 72'843 12'141 16'187	**3**

(d) Raw water reservoir-1	4	32'375	
location	8	36'422	
(e) Surface water treatment			
plant-1 location	9	28'328	
(f) Ground water central storage		20'234	
reservoir & treatment plant-1	7		
location.	5	8'094	
(g) Local water reservoirs-5			
locations	2		
(h) Solid waste disposal yards-3			
locations			
(i) Central liquid waste disposal			
plant-2 locations			
(j) gas metering stations-4			
locations			
Total	**81**	327'796	
6. Roads including Drains & Culverts:			**10.7**
(a) Major roads-13.6 km length(37 meter right of way)	124	501'811	
(b) Other roads-25.1km length(25 meter Right of way)	155	627'263	
Total	**279**	112'9074	
7. Residential/Housing area:			**6**
(a) Southern block	22	89'031	
(b) Western block	150	607'029	
Total	**172**	696'060	
8. Sport facilities, recreation area, park including Golf course:			**8.5**
(a)18 holes Golf course with related facilities	190	768'903	
b) sport facilities, recreation area, park etc.	30	121'406	
Total	**220**	890'309	
9.Green belt along the periphery with security passage:	**59**	238'765	**2.2**

Green belt with security passage along periphery-23.77km length,10 meter average wise			
10. Area not suitable for construction:			**8.9**
(a) Hill slopes between area of	130	526’092	
different formation levels and			
around Marine Academy			
(b) Mandatory space along main	22	89’031	
gas pipe line , 4.37km length,12			
meter wide including area not			
suitable for construction due to		129’500	
gas pipe line.	32		
(c) Scattered strips of land		121’406	
around existing graveyards	30		
(d)Scattered strips of land in		68’797	
different locations	17		
(e) Existing water passages(drainage, canals)			
Total	**231**	934’825	
11.Water Bodies:			**1.5**
(a) Lakes-3 locations	32	129’500	
(b) Ponds-4 locations	7	28’328	
Total	**39**	**157’828**	
Grand Total	**2’584**	**10’457’448**	

B. Area allocation for each type of industries at KEPZ

Categories of Industries expected to be setup at KEPZ

Sl No	Major Categories of Industries	Likely number of Industries	Total Demarcated Area for each industry type (Acres)	Total Demarcated Area (m^2)
1	Electrical equipment & components, electronics items, assembly, manufacturing of electronics components, computer peripheral, semi-conductor items etc.	65	90	364’217.4
2	Software development, IT and R&D type industries	52	50	202’343
3	Scientific measuring instruments & precision tools, optical goods, laboratory ware, musical instruments etc.	45	25	101’171.5
4	Jewellery industries and precious/semi -precious stone cutting	25	15	60’702.9
5	Engineering products and equipment, machine tools, automotive parts	25	50	20’2343
6	Leather products and shoes, bags, jackets etc.	45	120	485’623.2
7	Sports goods, toy manufacturing, footwear	50	100	404’686
8	Textile including woven and knitted fabric, polyester knitting	95	322	130’3089

	(dyeing and finishing) textile weaving, sweater (knitting and finishing),specialized garments, garment accessories			
9	Pharmaceuticals products	20	60	242’811.6
10	Gas-based industries, chemical products	15	150	607’029
11	Agro-based industries like fruit & vegetable processing /packaging for export, hi-breed crop / vegetable seeds production, tea (blending and packaging),jute products, organic fertilizer production, garden and farm equipment manufacturing ,flower and ornamental plants production, flower and ornamental plant processing and preservation for export etc.	40	200	809’372
12	Ceramic industries	5	50	202’343
13	Construction materials	10	40	161’874.4
14	Port related services & Business, ship chandler items	8	20	80’937.2
15	Space for standard industry building		47	190’202.4
	Total	**500**	**1’339**	**5’418’746**

C. Estimation of Gas Requirements for selected industries

Major categories of probable Industries	Area demarcated acres	% of Thermal on the total energy requirement	Operating hours per day	Gas requirement MWh_{th}/day	Equivalent m^3/day	Total requirement Million m^3/yr
Textile (Fabric Dyeing & Coating) (est.)						
	84	88%	24	1’485	140’586	46
Shoe factory	100	70%	20	311	29’444	10
RMG	64	1%	10	1	62	0
Light Chemical	150	37%	24	143	13’542	4
Insulation (Polyfill)	20	60%	12	36	3’407	1
Ceramic	50	90%	24	1’080	102’214	34
Nylon & Polyester Weaving (est.)	64	60%	24	232	21’942	7
Grand Total					**311’197**	**102**

D. Biomass flow

Biomass-Fraction	mass-flow	DM	DM	oDM	oDM
	t/a	%	t/a	% DM	t oDM/a
Rice Straw	200	80.0%	160	85%	136
Rice husk	80	80.0%	64	85%	54
slurry of cattle breeding	15'000	10.0%	1'500	80%	1'200
sewage of toillet	2'600	15.0%	390	70%	273
organic waste of household	730	25.0%	183	75%	137
kitchen residues YO (KEPZ)	16	25.0%	4	75%	3
kitchen residues YO (extern)	16	25.0%	4	75%	3
landscaping material (gras etc.)	100	15.0%	15	85%	13
	18'742	**12.4%**	**2'320**	**78%**	**1'819**

E. Potential without extern biomass (assessment A)

		slurry of cattle breeding	sewage of toilet	separate organic waste of households	organic residues YO catering	Rice Straw	Rice husk	**Total**
Input digester								
mass	t/a	14'000	5'000	730	32	200	80	**20'042**
DM	%	8.0%	5.0%	30.0%	25.0%	75.0%	80.0%	**9.0%**
	t/a	1'120	250	219	8	150	64	**1'811**
oDM	% DM	80%	70%	75%	75%	85%	85%	**79%**
	t oTS/a	896	175	164	6	128	54	**1'423**
Degradation	% oDM	50%	50%	55%	60%	25%	25%	**47%**
	t oDM/a	448	88	90	4	32	14	**675**
Output digester								
oDM	t/a	448	88	74	2	96	41	**748**
DM	t/a	672	163	129	4	118	50	**1'136**
H_2O	m3/a	12'880	4'750	511	24	50	16	**18'231**
Fertilizer	t/a	13'552	4'913	640	28	168	66	**19'367**
DM	%	5.0%	3.3%	20.1%	15.5%	70.3%	75.9%	**6%**
Biogas								
Produktion (average)	l/kg oDM_{IN}	300	300	600	700	150	200	**319**
	Nm^3/a	268'800	52'500	98'550	4'200	19'125	10'880	**454'055**
	Nm^3/d	736	144	270	12	52	30	**1'244**
	Nm^3/t substrate	19	11	135	131	96	136	**23**
	$Nm^3/t\ oDM_{degr.}$	600	600	1'091	1'167	600	800	**673**
Methan percentage	%	57%	57%	60%	60%	55%	55%	**57%**
Spezific heat value	kWh/Nm^3							**5.7**
Energy content of the biogas	kWh/a							**2'603'249**
Total Combustion power	kW							**297**
Electrical efficiancy	%							**38.5%**
Electrical power	$kW_{el.}$							**114**
Electrical energy	$kWh_{el.}/a$							**1'002'251**
Thermical efficiancy	%							**42.0%**
Thermical power	$kW_{th.}$							**125**
Thermical energy	$kWh_{th.}/a$							**1'093'364**

F. List of Light Electrical Loads of Young one Shoes at CEPZ

Unit :YSS	Total load	2745 kW		
Name of the Equipment	**Phase**	**Qty.**	**total load(kW)**	**Load /unit(W)**
Lighting load (double types)		3487	62.77	18
Hot air blower		54	29.7	550
Exhaust fan		70	28	400
Ceiling fan		658	17.55	26
exhaust fan (oil)		11	4.95	450
Halogen light		12	4	333
Computer M/C		26	3.47	133
Computer M/C		28	2.8	100
lighting load single types		147	1.42	10
Pedal Stand Fan		19	1.14	60
Lighting load (2`)		80	0.96	12
Computer M/C		10	0.23	23
Exhaust Fan		2	0.21	105
Bulb		6	0.2	33
Ceiling fan		8	0.16	20
projection tv		1	0.08	80
			Total 157.64	

G. Coal reserves

Coal Reserves in Bangladesh						
Coal Deposit	**Depth of Deposit (meters)**	**Estimated Reserve (mt)**	**Recoverable By underground Mining (mt)**	**Recoverable by open cast Mining (mt)**	**Total Recoverable Reserve (mt)**	**Equivalent Gas (Tcf)**
Jamalganj	800-1150	1'053	168	-	168	4.42
Barapukuria	119-504	390	64	270	270	7.10
Khalashpir	257-480	685	109	480	480	12.63
Phulbari	140-350	426	68	360	360	9.47
Digiphara	328-455	200	32	140	140	3.68
Total		**2'754**	**441**	**1250**	**1418**	**37.30**

H. Price and Tariff of Energy in Bangladesh

Gas Tariff

Tariff Rate for gas (effective from August 2009)

Consumer Category			Rate (BDT/m³)	Rate[28] (USD/ m³)
A. Non-bulk	1. Domestic	a. Metered	5.16	0.074
		b. Un-metered	Table 2	Table 2
	2. Commercial		9.47	0.137
	3. Industrial		5.86	0.085
	4. Seasonal		8.22	0.118
	5. Tea-state		5.86	0.085
	6. CNG		9.97/16.75	0.144/0.242
B. Bulk	7. Power (PDB/IPP)		2.82	0.041
	8. Fertilizer		2.58	0.037
	9. Captive Power/SIPP		4.18	0.060

Tariff Rate for electricity un-metered appliances

Sl. No.	Item	Rate (BDT/month)	Rate (USD/month)
1	Cooker - 1 burner	400	5.77
2	Cooker – 2 burners	450	6.49
3	Additional burner	98	1.41
4	Oven (each)	215	3.10
5	Additional oven	108	1.56
6	Grill (each)	205	2.96
7	Additional grill (each)	108	1.56
8	Water heater (20 Gal.)	428	6.17
9	Water heater (Above 20 Gal.)	535	7.72
10	Dryer (each)	645	9.31
11	Refrigerator	428	6.17
12	Gas light (garden)	98	1.41
13	Gas light (inside room)	50	0.72

[28] Bangladesh Bank exchange rate : 1USD= 69.31 BDT (3rd June 2010)

<u>Electricity Tariff</u>

Changes in Electricity tariff by Bangladesh Power Development Board (BPDB) Effective from 1st March, 2010

Sl. No.	Consumer Category	Rate/Unit (BDT)	Rate/unit (USD)	Service Charge (BDT/month)	Demand Charge (BDT/kW/month)
1	**Category A: Domestic** a. 1st Step: 000-100 Units b. 2nd Step: 101-400 Units c. 3rd Step: >400 Units	2.60 3.30 5.65	0.038 0.048 0.082	1 Phase: 6.00 :USD 0.087 3 Phase: 27.00 :USD 0.39	BDT 12.00 USD 0.173
2	**Category C: Small Industry** a. Flat b. Off-peak c. Peak	4.35 3.50 5.95	0.063 0.051 0.086	BDT 63.00 USD 0.909	BDT 37.00 (USD 0.534) (Applicable for approved demand of more than 40 KW)
3	**Category E: Commercial & Offices** a. Flat b. Off-peak c. Peak	5.58 4.05 8.45	0.081 0.058 0.123	1 Phase: 6.00 :USD 0.087 3 Phase: 27.00 :USD 0.39	BDT 22.00 USD 0.317
4	**Category F: Medium Voltage, General Category (11KV)** a. Flat b. Off-peak c. Peak	4.17 3.43 7.12	0.060 0.049 0.103	BDT 355.00 USD 5.12	BDT 42.00 USD 0.606 (For max demand)
5	**Category G-2: Extra High Voltage, General Category (132KV)** a. Flat b. Time: 2300-0600 c. Time: 0600-1300 d. Time: 1300-1700 e. Time: 1700-2300	3.10 1.63 2.72 1.82 5.94	0.045 0.023 0.039 0.026 0.086	None	BDT 37.00 USD 0.534 (For max demand)
6	**Category H: High Voltage, General Category (33KV)** a. Flat b. Off-peak c. Peak	3.92 3.33 6.82	0.057 0.048 0.098	BDT 410.00 USD 5.91	BDT 37.00 USD 0.534 (For max demand)
7	**Category J: Street Lights & Pumps**	3.98	0.057	BDT 205.00 USD 2.96	BDT 37.00 USD 0.534

1. This tariff for consumers of these categories will come into effect from 1st March, 2010.

2. For consumers of other categories, retail rate per unit of electricity, service charge and demand charge will remain same as the tariff effective from 1st March, 2007. [Enclosed herewith]
3. This tariff will continue to apply till further notice.

<u>Price of Petroleum Products</u>

Consumer end price of petroleum products

(Effective from 15th March, 2009)

Sl. No.	Petroleum Type	Rate (BDT/unit)	Rate (USD/unit)
1	Diesel	44/Lit	0.635/lit
2	Kerosene	44/Lit	0.635/lit
3	Octane	77/Lit	1.11/lit
4	Petrol	74/Lit	1.07/lit
5	LPG	850/12.5kg cylinder	12.26/12kg cylinder
6	Furnace Oil	26/Lit	0.375/lit

<u>Coal Price</u>:

US Dollar 60.00 per Metric ton (1000 kg) as fixed by the Government

I. Preliminary Cost Estimation and Technical Requirement Estimation of a 10 MW Power Plant for an Industry

- Land Purchase, registration and Development
- Building and Civil Construction
- Furniture and Fixtures
- Machinery and Equipment
- Erection and Installation Cost
- Transportation
- Power and Fuel
- Security and licensing
- Preliminary expenses
- Manpower Expenses

Major cost components are described briefly:
Land Building and Civil Construction (Common for all alternatives)

Total estimated Cost	MBDT 50

Typical Suppliers of Engine Generators with ATS, Control panel, cooling system, after-sales and installation service, warranty, repair and routine maintenance contact etc.:

1 Caterpillar
2 Wartsilla
3 Cummings
4 Gascouer
5 Mitshubishi
6 Yanbacher
7 Others

Typical Supplier of Transformer, Switchgear and Substation Equipment

1 Energy Pac Ltd Bangladesh,
2 Siemens Bangladesh Limited,
3 GE Bangladesh Limited and others.

Cost comparison for alternative options for power generation:

No.	Expenditure Heads	Natural Gas Gensets	HFO Gensets	Diesel Gensets	Dual Fuel (NG & HFO) Gensets	Dual Fuel (NG & Diesel) Gensets
1	Engine Generator	350	150	150	450	450
2	Balance of Plant (BOP)	10	10	10	10	10
3	Sub station	15	15	15	15	15
4	stand by supply Transformers and Substation Equipment's	7.5	7.5	7.5	7.5	7.5
5	Control and Power Cables	20	20	20	20	20
6	Fire fighting and Alarm System	2.5	2.5	2.5	2.5	2.5
7	Spares and Initial Fuel and Lube Oil Cost	5	5	5	5	5
8	Installation	5	5	5	5	5
9	Freight, Carrying cost, Taxes	5	5	5	5	5
10	Licensing and permission	10	10	5	5	5
	TOTAL	**430**	**230**	**225**	**525**	**525**

Other Costs: 5 MBDT, which includes,

1 Different Types of Pipes and Fittings,
2 Air coolers,
3 Domestic Water line,
4 Emergency Lighting,
5 Computers,
6 Plumbing and
7 Effluent Treatment (ETP) reservoir etc.

Overhead Costs:

Human Resource	No.	Avg. Monthly Salary per person in BDT	Employee Expenses
Plant Manager	1	50'000	50'000
Plant Engineer	4	40'000	160'000
Asst. Engineer	6	30'000	180'000
Plant Operators	12	22'500	270'000
Security Guard	9	15'000	135'000
Attendant	4	15'000	60'000
Cleaner	4	15'000	60'000
Gardener	2	15'000	30'000
TOTAL	**42**		**945'000**

Lube Oil and Water coolant cost:

20 litre of lube oil per day per 1MW engine = estimated cost 5000/- per 1MW engine (normally more for older plant & less for newer plant).

50 litre of water coolant per day for total 10 MW engines = estimated cost 2500/- (Normally more for older plant).

Spares: BDT 3 lacs per month

Repair and Maintenance cost:

	1st year	2nd year	3rd year	4th year
Building	BDT 2 lacs	BDT 2.5 lacs	BDT 3 lacs	BDT 3.5 lacs
Machinery	BDT 5 lacs	BDT 7.5 lacs	BDT 10 lacs	BDT 15 lacs
Overhauling	As per Engine manual	As per Engine manual	As per Engine manual	As per Engine manual

Depreciation:

Building	5% per year
Machinery	10% per year
Other Assets	20% per year

Interests:
Interest for capital loan if any 13.00 % per annum
Interest rate for working capital 13.00 % per annum

Operating Life of the Plant:
15 years without any major BMRE and 20 years with BMRE

Construction and Implementation Time:
6-9 months

Environmental Impact:

Requirements:

Air Quality Standards: *Density in micrograms per m cube*

Types of Area	Suspended Particle matter (SPM)	Sulfur Dioxide	Carbon Monoxide	Nitrogen Oxides
Industrial and mixed	500	120	5’000	100
Commercial and mixed	400	100	5’000	100
Residential and rural	200	80	2’000	80
Sensitive	100	30	1’000	30

Source ECR (1997) DoE

Noise Quality Standards (Requirements):

Zone Class	Limit in decibels (dB)	
	Day	Night
Silent Zone	45	35
Residential Zone	50	40
Mixed Zone	60	50
Commercial Zone	70	60
Industrial Zone	70	70

Environmental Impact study is recommended before undertaking the project as per EIA methodology

Possible Impacts:

Short Term Impact:

It is anticipated that most of the short term impacts will be of minor category. When the construction and installation activities will be completed, these impacts would be overcome easily.

Long Term Impact:

As the proposed power plant will use modern manufacturing technique, it will not bring any sever adverse impacts to the adjacent environment. It is necessary to mention that the project will be capable to maintain the different emission standards of the environmental parameters recommended by the Department of Environment, Government of the People’s Republic of Bangladesh. Most of the long term impacts are positive. If the project is implemented it will create employment and enable the proposed factory without power outage. This will add to the economy of the country. Although some long term impacts are adverse to the natural environment, most of them have either minor impacts or might be treated easily.

J. Details on energy require for shoe production;

- The total energy requirement of YO Shoes (per pair) is 4.6 kWh (2kWh$_{el}$ & 2.6 kWh$_{th}$).
- The most energy intensive of production process is that of outsole and midsole.
- 53.67% of the total energy demand is in the form of thermal and the rest electrical.
- The shoe factory under scrutiny has both thermic oil heaters and steam boilers.
- 12.89% of the thermal energy demand is met by the thermic oil heater.
- A 5 ton/h capacity boiler supplies steam at a rate of 1875 kg/h. Steam being at 5.0 bar (at a temperature of 150°C).
- The output of the thermic oil heater is estimated to be 588 kW
- Total annual electricity demand: 85'247.2 MWh$_{el}$ p.a.
- Total annual heat demand for sole: 98'752.8 MWh$_{th}$ p.a.
- Steam (at the point of usage) is saturated steam 5 bar at 150°C
- Temperature of boiler feed water would be 30°C.
- Requirement per sole factory: one 5 ton/hour boiler which is equivalent to energy input at a rate of 4.0 MWh$_{th}$.
- 1 MWh$_{th}$ costs USD 20.00 (105 Nm^3 gas (USD 10.00); investment costs (USD 9.00) and misc costs (USD 1.00))
- 1 MWh$_{el}$ costs USD 66.66 (this is off the grid). If generated in gas gensets it will be about USD 28.00. This is even without co-gen benefit.
- If generated in diesel gensets (as it is planned), it will be about 133 USD per MWh$_{el}$
- Diesel: USD 0.64/l
- If Waste Heat Recovery Boilers are installed, the overall efficiency of the generators can be risen by 30%, using their waste heat for steam production
- The output of 1 MWh$_{th}$ could then be achieved with the cost of only 14USD

K. Typical Hybrid Grid System