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PROSPECT OF CAPTIVE POWER GENERATION IN BANGLADESH

C. A. A. Atis[1], M. Sarker[2] and M. A. R. Sarkar[3]

[1-3]Department of Mechanical Engineering
Bangladesh University of Engineering and Technology
Dhaka, Bangladesh.

[1,*]cyrus.arupratan@gmail.com, [2]msshuva@gmail.com, [3]rashid@me.buet.ac.bd

Abstract- *In Bangladesh, economic growth is being impeded both by poor electricity supply quality and by electricity supply interruptions, particularly in the peak period. To reduce the gap between supply and demand for electricity and to make best use of energy resources Captive Power generation is the option to look out for. This paper gives a brief overview of the power generation sector involving Captive Power and its prospect in Bangladesh. The paper also discusses the policy of Government of Bangladesh regarding captive power generation. The various types of Captive power plants like Internal Combustion Engine type, Cogeneration for the industries involving process heating etc. are discussed. The present scenerio of Captive power generation are discussed and some measures towards its promotion, like energy banking and energy wheeling are recommended.*

Keywords: Captive power, Power plants, Cogeneration, Energy banking, Energy wheeling

1. WHY CAPTIVE POWER

Captive Power refers to generation from a unit set up by the industry for its exclusive consumption. Bangladesh has made great strides over the past decades, including steady economic growth, improved macroeconomic indicators, integration with the world economy and progress on key social indicators like reduction of population growth, poverty and improvement of rural infrastructure. But Bangladesh has fallen short of its growth potential compared to some other low-income countries in part because of inadequate infrastructure, especially on the power sector. An adequate electricity supply plays a central role in development and realization of the country's economic goals. But in Bangladesh power sector problems including low power generation and coverage, poor electricity supply quality and supply interruptions, particularly in the peak period are persistent. The electricity tariff charged by electric utilities is increased very frequently. Moreover the reliability of electric supply from the grid is very poor. This hampers the industrial sector which is one of the largest consumers of electrical energy. In addition to forced outages, industrial sector has also to face long power cuts especially during agricultural season and other periods of peak demand.

In view of above factors a large number of industries in Bangladesh have switched over to their own generating plants located within their own premises. This method of generation is known as Captive power generation and its use is increasing day by day. Earlier captive power plants were used only as standby source of electric supply to feed the industry when power from grid was not available. But now many industries generate their requirements from their own captive power plants.

2. SCOPE OF CAPTIVE POWER

Captive power is used for certain advantages and for different purposes.

2.1 Advantages

The use of captive power is increasing day by day because of the following advantages:

(a) As the electric utilities continue to raise their electricity tariff frequently, captive power may be cheaper than power from grid.

(b) Bangladesh is not in a position to set up new power plants due to many constraints. As such many independent power producers (IPP) are setting up medium and big size power projects for supplying power to the grid. This power is very costly due to high rate of return demanded by IPP. Therefore captive power generation is likely to become an increasingly cheaper alternative.

(c) Since the power is consumed within the industry, there are no transmission and distribution losses.

(d) The problem of electricity theft is eliminated.

(e) Generally there is no extra cost on infrastructure like roads, land etc.

(f) The overhead costs are low.

(g) If the captive power plant is designed, set up and operated properly, the forced outages can be lower than in grid supply. Moreover there is no problem of power cuts.

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2.2 Captive Generation Options

Captive power generation has a number of options available. Some of these are:

(a) Captive power plant set up by an industry for its own use only.

(b) Captive power plant for meeting energy requirements of industry as well as for supplying surplus energy to utility.

(c) Captive power plant for meeting energy requirements of industry and selling surplus energy to neighboring industries.

(d) Captive power plant for meeting energy requirements of industry and for selling surplus energy to other industries as well as utility.

(e) Captive power plant set up as a cooperative venture by a number of industries.

(f) Captive power plant set up by a generating company and supplying power to many industries in the area.

3. PRESENT SCENARIO OF POWER SECTOR IN BANGLADESH

At present per capita electricity consumption in Bangladesh is 292 kWh [1] which is one of the lowest in the region. Generation capacity could not be increased accordingly during past years which have resulted in increasing power shortage in the country. Table 1 shows us the present power sector scenario in Bangladesh in a nutshell:

Table 1: Power sector scenario in Bangladesh [1] [2]

Power sector at a glance	
Generation Capacity (December 2012)	8525 MW
Public Sector	4794 MW
Private Sector	3731 MW
Max. Demand (4th August, 2012)	6350 MW
Max. Generation (12th July2013)	6675 MW
Transmission Line (230 & 132kV)	8949 Ckt. km
Distribution Line (33kV & below)	33,617 km
No. Of Consumers	2,432,055
Access to Electricity	60%
Per capita Generation (KWh)	292 kWh

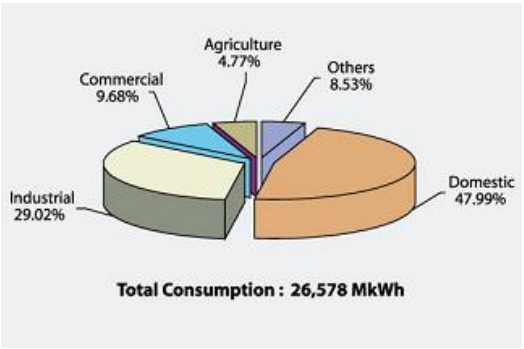

Fig.1: Consumption Pattern of Bangladesh [3]

Figure 1 shows us that a considerable percentage of energy consumption belongs to the industrial sector in Bangladesh, also the growth of the industrial consumer (small and large) is almost 15.81% of the total growth in consumers [4] .So any fluctuation or shortage in power has a major impact in the country's economic growth.

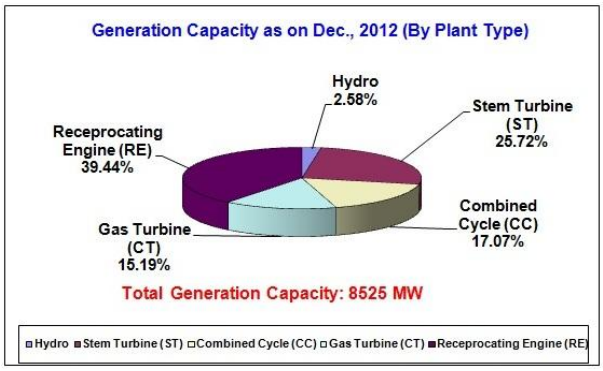

Fig.2: Types of plants installed in Bangladesh [2]

From figure 2, it is seen that a higher percentage of plants belong to the Reciprocating Engine type. Gas turbine, steam turbine and combined cycle plants are also contributing while a small amount is produced by hydro power plant.

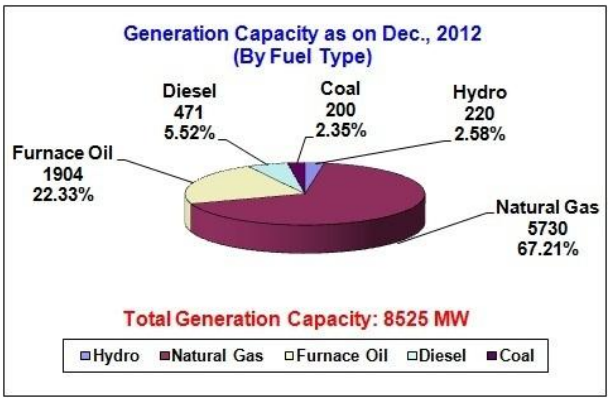

Fig.3: Power generation capacity by fuel types [2]

From figure 3 it is clearly seen that there is a huge dependance on Natural Gas which is a matter of great concern since gas usage is increasing day by day. It is estimated that from year 2012-13 to 2013-14 gas demand will increase from 1061.5 bcf (billion cubic feet) to 1224.4 bcf [5]. The gas reserve upto December 2011 is 16.74 tcf (trillion cubic feet) [6] and according to experts the reserve will last only till 2022 if no new gas fields are discovered [7]. After that there will be a huge crisis in the power sector regarding the Natural Gas consumption and likely to affect the whole power sector pretty badly. So this is the high time to invest in Captive plants in order to mitigate the effect of fuel scarcity in near future and reduce the dependance on Natural Gas by using captive plants using furnace oil or diesel.

4. GOVERNMENT POLICIES

Adequate electricity supply plays a central role in development and realization of the country's economic

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goals. To reduce the gap between supply and demand for electricity, and to make best use of energy resources, the Government of Bangladesh, pursuant to its powers under section 24(1) of BERC Act, and having consulted with the Commission pursuant to section 24(2) of BERC Act, declared policy Guidelines to (a) harness the surplus capacity of captive power plants, and (b) permit electric utilities to purchase electricity from captive power plants.

The key points of the policy [8] are:

(a) The tariff proposal by the CPP shall contain break up of all components including fuel cost component. The Tariff shall be approved by the BERC.

(b) The interconnection network required for the supply of electricity to the contracted electric utility shall be built by the Owner of Captive Power Plant. The cost of inter-connection with network including switchgear, metering, protection, etc. will be borne by the Owner of Captive Power Plant.

(c) For selling electricity to any Distribution Licensee other than the Host Distribution Licensee, the CPP may transmit power through existing transmission and distribution network subject to availability of adequate network capacity. In that case the CPP will have to pay the wheeling charges, as fixed by the BERC, to the owner of the network.

(d) The Voltage of supply during steady flow of power to the network of the Entities from Captive Power Plant shall be subject to approval by the entities, but shall normally be as mentioned in table 2:

Table 2: Voltage of supply for different plant capacity [8]

Plant Surplus Capacity	Voltage Level
Less than 1 MW	0.4 kV/ 11 kV
Over 1 MW to 5MW	11 kV/ 33 kV
Over 5 MW to 10 MW	33 kV
More than 10 MW	33 kV or above

(e) Frequency for power supply will be 50 Hertz. Variation of frequency and voltage shall be in accordance with the Grid Code of Bangladesh. The Captive Power Plant must have arrangements for handling, absorbing and suppressing abnormal fluctuations in respect of voltage and frequency.

(f) The Power Factor of power delivered by the power plant shall normally be 0.8 (Lagging).

(g) Appropriate protections are to be installed by the CPP to protect its own plant as well as the Grid or other voltage level network depending on the Delivery Point and associated equipment of the Utility.

(h) Proper synchronization shall be responsibility of owner of power plant and any damage to the property of the purchaser for improper handling by the CPP will be compensated as per decision of BERC.

(i) The CPP will take appropriate measures to prevent inadvertent power flow. For any undue net flow of energy to the Utility, the Utility shall not pay for such power.

(j) No banking of energy will be permitted during the period of electricity supply to the Utility by the CPP.

5. TYPES OF CAPTIVE POWER PLANTS

The captive power plants can be classified as: Steam plant, gas turbine plants, diesel engine plants, cogeneration plants, wind cum diesel plants.

5.1 Steam Turbine Plants

Generally these captive plants may be around 20 MW. These plants are set up by large size industries. Some industries e.g., sugar industry can use bagasse (waste dry sugarcane left over) as fuel in their steam captive power plants. Its use as fuel may reduce the operating costs of such captive power plants considerably. Also it may be used in combined cycle which is a great advantage. [9] In Bangladesh steam turbine plants are used as captive power plants in sugar mills e.g. Charasindhu sugar mill (2.5 MW), Fertilizer industries e.g. Jamuna Fertilizer in Tarakandi (8 MW & 16 MW).

5.2 Gas Turbine Plants

These plants are also used in large sizes. Some industries e.g., petrochemicals have easy access to gas and liquid fuels and, therefore, these industries should prefer captive power plants having gas turbines which use gas or liquid fuel. Use of gas turbines also offers opportunities for combined cycle plants. The land requirements for gas turbine plants are much lesser than that for steam power plants. So these plants can be very popular in medium & large industries. Also gas turbine plants can start fairly quickly in case of high demands. In Bangladesh gas turbine plants are used as captive power plants in BEXIMCO Industrial Park (4 MW), fertilizer plants e.g. Ghorasal Fertilizer Factory (15 MW) & Jamuna Fertilizer in Tarakandi (4 MW).

5.3 Gas Engine Plants

For industries this can be a very attractive option as Bangladesh still has a good reserve of natural gas [6] and unlike gas turbine plants, they can be from small to medium sizes, designed for stationary, continuous duty operation. They are known for their high efficiencies, low emissions, durability, high reliability and they can run on natural gas, biogas, combustible industrial waste gases etc. and can also offer opportunities for cogeneration which is a great advantage. [9] Bangladesh University of Engineering and Technology uses gas engine to produce power (2 ×1 MW+1×2 MW= 4 MW). Also gas engine plants are used in pharmaceutical industry, textile industry, garments etc.

5.4 Diesel Engine Plants

Diesel engine plants are generally used in sizes of about 2 MW or more. These plants are used for meeting the plants total requirements, peak requirements as well as stand by units.

These plants have the following advantages: [9]

- Low capital investment.
- Small space requirement.
- Better efficiency
- Short gestation period.
- Quick start up time.

Both four stroke and two stroke engines may be used. The special advantages of two stroke engines is

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their ability to run on even residual liquid fuels which are very cheap and thus represent a cost effective option. In Bangladesh diesel engine is used for captive power at British American Tobacco Bangladesh (7.2 MW), Jamuna Fertilizer in Tarakandi (0.7 MW).

5.5 Cogeneration Plants

A cogeneration facility produces two or more types of useful energy e.g., electrical energy and steam. The efficiencies of cogeneration plants can be very high thus leading to overall economy and conservation of fuel. A cogeneration plant may be steam – gas turbine plant with waste heat boiler, combined cycle cogeneration plant, biomass fuel plant, diesel engine plant etc. The basic idea is to use as much energy (of the fuel) as possible. The initial cost of a cogeneration plant is more than that of an electric power plant. However, if the industry requires both electricity and steam, the cost of installation of a separate steam generator is saved. This saving along with high efficiency (and lower fuel cost) makes the cogeneration an attractive option. Moreover pollution created by cogeneration plants is lesser than that of other plants.

In Bangladesh, cogeneration plants are used in fertilizer industry, sugar mills and textile spinning mills. In fertilizer industries, the main raw materials for urea production are ammonia and carbon dioxide, which are produced in ammonia plant using natural gas, steam and air as raw materials. The natural gas is used as fuel in boilers to produce steam and to generate electricity for the plants own use.

The sugar mills produce bagasse as by-product, which is the main fuel for sugar mill boilers. The boilers produce steam for use in manufacturing process of the sugar mill and for generating electricity. [10]

The cogeneration potential in the largest spinning mills has been analyzed in UNESCAP 2000. According to this, the mills operate 24 hours a day, for 360 days a year. The mills require both electrical energy and thermal energy for production. So cogeneration is used here with generation capacity of 6.4 MW. [10] Also in BEXIMCO Industrial Park, the gas turbine plant has cogeneration facilities and the exhaust is used in a vapor absorption refrigeration system.

6. ENERGY BANKING

Regarding captive power generation, the captive power generator is a depositor and the utility of the area is the bank. Energy banking is very necessary to promote captive generation. The industry, having captive facility may not have constant electricity demand at all times. It would be beneficial if the excess energy can be banked to the utility and withdrawn at the time of need. Most utilities in advanced countries provide free banking facility to promote cogeneration. The only restriction generally imposed is that energy cannot be withdrawn at the time of utility's peak. Some utilities charge a certain amount per MWh of energy deposited and withdrawn. Generally a maximum time limit within which the deposited energy must be withdrawn is also fixed. In Bangladesh, energy banking is supported with the restriction that no banking of energy is to be permitted during the period of electricity supply to the Utility by the CPP. [8]

7. ENERGY WHEELING

Energy wheeling means using someone else's transmission system for energy transfer. Evidently the use of transmission facility has to be paid for. In Bangladesh, energy wheeling is done between the utility and captive generators.

Many times a captive generator has excess capacity available which another industry can use. But these industries may be situated some distance from each other and neither of them may own a transmission or distribution system. In such a situation they use the system of the area utility for this energy transfer. Figure 4 shows this configuration. Both industries A and B are situated in the area of utility. A is a captive plant owner and has surplus electrical energy available. B wants to buy this surplus from A. They use the transmission/distribution system of the utility for this energy transfer. Another arrangement could be that A sells energy to utility and B buys energy from utility. This does not require any wheeling transactions.

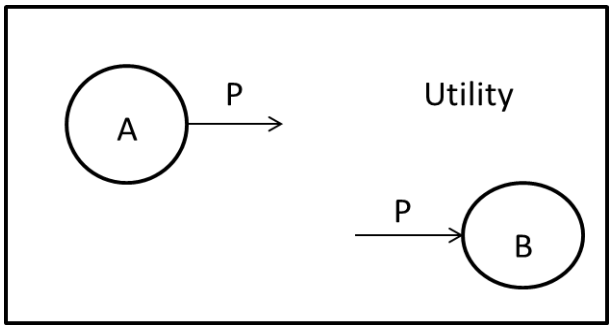

Fig.4: Energy wheeling between industry through utility

8. FINANCING OF CAPTIVE POWER PLANTS

The financial aspects of a captive power plant are somewhat different from those of utility owned. The important fact is that overall generation cost should be lower or at least comparable with that charged by the utility and reliability of electric supply should be good so that the production does not suffer. To a large extent the financing depends on the size of the plant.

When the size of plant is less than 5 MW or so, the plant should be set up by the industrial owner from his own resources or from borrowings from banks etc. because of the reason that the owner is entitled to claim depreciation and thus save taxes.

For mid size plants (5 MW to 50 MW range), the industry may set up separate captive power company. The industry then can invest only a part of the total equity. The remaining amount is raised through shares, debentures etc. This separate power company can claim many incentives e.g., five year tax holiday, preferential duty treatment etc.

When the size of captive plant is large, the plant may be set up by the equipment supplier company.

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In such cases the host is not required to make any investment. The plant can be designed, constructed and operated by the equipment supplier. The host has to only guarantee the use of entire electricity generated at the negotiated price. Since the equipment supplier has expertise in design and construction of plants, this option is more economical in many cases.

In all the above cases the success of the captive power plant depends on the following factors:

(a) The financial position and balance sheet of the host company.

(b) Proper fuel linkages.

(c) Proper design, installation and operation of the plant.

The financing is very easy if the captive plant is a cogeneration plant (e.g., bagasse fuel heat and power plant) or a non-conventional source power plant. Subsidies, low interest loans etc. make such plants very attractive.

9. CAPTIVE POWER SCENARIO IN BANGLADESH

In Bangladesh there are 1561 plants that produce total 2807.84 MW of electricity. [11] Among them 652 plants are larger than 1 MW who produce 2454.88 MW and rest of the plants are less than 1 MW. The plants less than 1 MW get some waiver from BERC. Without these there are many small units in Bangladesh who don't have license from BERC. So approximately the total amount of captive power generation is 2700-2800 MW. [12] Table 3 shows the captive power generation capacity in Bangladesh:

Table 3: Captive Power generation capacity installed in Bangladesh [11]

Category	Capacity(MW)	Average Capacity(MW)
Larger than 1 MW	2454.88	3.81
Less than 1 MW	352.96	.456
Total	2807.84	

From figure 5, it is seen that in Bangladesh maximum captive power plants are based on gas. The plants which are less than 1 MW or very small use diesel or furnace oil but others use gas because Bangladesh has a high reserve of gas. But the overuse of gas poses an imminent threat of future fuel scarcity and interrupted power generation because of the following reasons:

- Increasing fuel price of gas, diesel, furnace oil
- Decreasing gas reserve (present reserve will last till 2022) [7]
- Lack of new invention of gas field
- Lack of intention of the power plant owners to migrate from natural gas to furnace oil/diesel

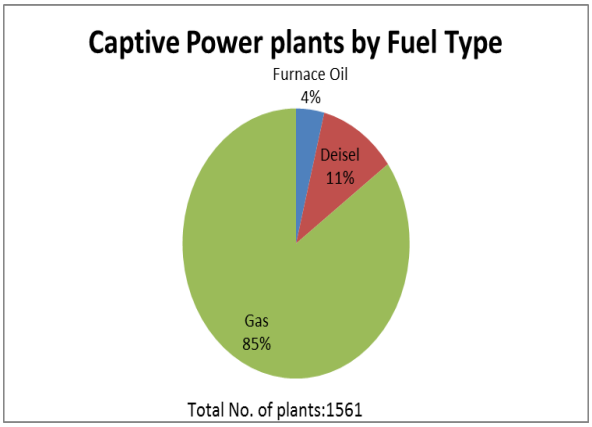

Fig.5: Captive power plants by fuel types [11]

10. ENVIRONMENTAL IMPLICATIONS

Despite the advantages, the growth of captive plants may be a concern for a clean environment. A large number of the small-capacity captive plants and the size of the plant has a definite influence on specific carbon emissions. Specific emissions can be decreased by using suitable fuels. It is seen that coal power plants has more CO_2 emission than natural gas, petroleum and biomass. [13] Also, emission control equipments are often not installed in small captive plants and emission from widely dispersed large number of small-capacity plants are difficult to monitor. Emission control technologies in small captive plants are not always economically viable and the distributed proliferation of the small captive plants makes emission monitoring by authorities difficult.

Key steps taken by Bangladesh Government for captive power [11] :

(1) Energy ministry has planned to convert the gas fired captive power plant to furnace oil to ensure that the industrial production does not face sudden halt amid fast depletion of clean energy reserves. They have called 2000 owners of captive power plant to make a decision about this issue.

(2) To utilize the operation of captive power plants the previous caretaker government had taken an initiative to purchase additional electricity of over 1000 MW from the plant owners for supplying to the national grid. But the move was faltered due to apathy from the captive plant owners.

11. FUTURE PROSPECTS OF CAPTIVE POWER GENERATION IN BANGLADESH

The installed capacity of captive power at present is about 2800 MW. The installed capacity is likely to grow every year in future. The reasons for a greater popularity of captive plants in future are:

- The gap between supply and demand is not likely to be bridged. It may in fact increase due to the fact that in some cases the expected addition in generation capacity may be delayed.
- The reliability of electric power from electric utilities is likely to become all the poorer as there seem to be no efforts to improve the

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distribution system which is the major contribution factor in outages.

- The tariff of electricity from electric utilities is likely to increase as can be seen from the recent electricity billing rates whereas generation cost of captive power is likely to remain more or less constant.
- Setting up and operating captive plants is likely to open new business opportunities and more new companies are likely to come up.
- As automation in industries is increased, power requirement especially in continuous process industries is likely to become more critical.

So it is easy to see a brighter future for captive power generation in Bangladesh at least in terms of popularity especially with IPPs. Hopefully it will mitigate the burning problem of power crisis and help out to build a bridge between the present supply and demand gaps.

12. SUMMARY AND RECOMMENDATIONS

For captive power generation becoming the key to solving the present power crisis, the following recommendations are made:

(a) Formulation of a well-integrated power policy which addresses the various issues like CPP policy, IPP policy, T&D policy, policy for private investments in power etc. so that captive power investors along with the other stakeholders gain as a whole. This will ensure an overall development of the captive power sector, which will in turn result to the development of Bangladesh economy.

(b) A large number of small industries in an area should join together to form a group and set up a group captive plant. This cluster of industries will all get sufficient energy from a single big power plant rather than a large numbers of small power plants.

(c) Categorization of large and small captive power plants needs to be implicated carefully.

(d) Smaller plants which have come up primarily as back-up power facilities need to be treated differently and encouraged to meet peak power demand to lessen the burden on the grid.

So in order to justify a brighter prospect of captive power generation in Bangladesh long term implications should be considered before launching into a huge nationwide implementation of small captive plants.

13. REFERENCES

[1] http://www.powerdivision.gov.bd/user/brec1/30/1, (22th July, 2013)

[2] http://www.bpdb.gov.bd/bpdb/index.php?option=com_content&view=article&id=5&Itemid=6, (22th July, 2013)

[3] Bangladesh Power Development Board, "Annual Report 2010-2011".

[4] Bangladesh Power Development Board, "Annual Report 2011-2012".

[5] http://www.petrobangla.org.bd/corp_planning.php# (23th July, 2013)

[6] Petrobangla, "Annual Report 2011".

[7] http://www.platts.com/latest-news/natural-gas/Dhaka/Bangladeshs-existing-gas-reserves-to-run-out-26046254, (23th July, 2013)

[8] Power Division, Ministry of Power, Energy and Mineral Resources, People's Republic of Bangladesh, "Policy Guidelines for Power Purchase from Captive Power Plant, February 2007".

[9] B.R.Gupta, *Generation of Electrical Energy*, S. Chand, 2006.

[10] M. Jalal Ahmed, N.N. Nargis and M.A.R. Sarkar, "Energy Co-generation and Decentralized Energy: Current Situation and Future Opportunities in Bangladesh", *Journal of Institution of Engineers, Bangladesh Multidisciplinary*, vol.mul-dis 28, no. 1, pp. 18-27, Dec. 2003.

[11] T. Masud, I. Kabir, *Captive Power Generation in Bangladesh*, B.Sc. Engineering Thesis, Bangladesh University of Engineering and Technology, March 2012.

[12] http://www.textiletoday.com.bd/magazine/81 (24th July, 2013)

[13] http://edis.ifas.ufl.edu/fe796 (24th July, 2013)

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