PRE-FEASIBILITY OF COGENERATION IN A PHARMACEUTICAL INDUSTRY IN BANGLADESH

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Abstract An investigation regarding the cogeneration potential in a typical pharmaceutical industry in Bangladesh was carried out. Information on steam and electricity consumption in the mill was collected through site visits and surveys via questionnaires. This factory operates 24 hours a day, for 340 days a year. Natural gas is used in boiler to generate steam that is required for the process. Historical energy consumption data shows that the power to heat ratio of the plant was 0.31. For average power to heat ratio of 0.31, three types of the prime movers i.e. steam turbine, reciprocating engine and gas turbine cogeneration system were considered. From the sensitivity analysis the potential cogeneration alternatives of the paper mill, the reciprocating engine power match option meeting power requirement of 875 kW appears to be the most suitable co-generation system. It represents an initial investment of 37.6 billion Taka (1 US$ = Tk 57) and leads to an internal rate of return of 41.8%.

INTRODUCTION

Bangladesh has acute shortage of primary energy resources, which is hindering the growth of the energy sector. Energy conservation in particular and cogeneration is considered to be an attractive proposition in this context. Apart for the benefits in terms of incremental energy supply, cogeneration offers prospects for improving capacity utilization of industrial equipment and economic advantages. The major energy source of Bangladesh is natural gas. Its reserve in about 15 trillion cubic feet. In addition to this an additional reserve of 2.5 trillion cubic feet of gas and oil in shallow waters of the Bay of Bengal in expected to be available for exploitation.

The present gas production is about 715 million cubic feet per day. Coal deposits at shallow seams (135 m) at Barapukuria is also being developed with a targeted annual output of 8 million tons. The entire amount of petroleum sproducts consumed in the country is imported in the terms of crude as well as refined product [Bangladesh National Energy policy, 1996].

About 86 percent of the total electricity production depends on natural gas. Present peak demand of electricity is around 2300 MW, while the generating capacity of grid as about 2900 MW [Sarkar et.al 1999]. The actual capacity is however much lower due to again of machines, problems of maintenance, availability of adequate fuel, frequent tripping of turbines and fluctuations in water at the sole hydroelectricity plant of the country. At present only about 30 percent of the population has access to electricity. According to the National Energy Policy the annual average growth in peak demand will be in access of 10% in order to help meeting the demands in various end use sectors of economy. It is also estimated that capacity addition of 300-400 MW annually would be required even for meeting the needs of a modest growth in demand [Sarkar et.al 1999]. Today in the developed as well as the developing countries, conservation in general and cogeneration in particular are being given increasing attention to supplement the need for building new power plants. This issue needs due impetus in the context of the energy balancing of Bangladesh.

Cogeneration (combined heat and power or CHP) is set to play a major role in post-Kyoto carbon reduction strategies around the world. As well as cutting energy costs for a wide range of users, cogeneration uses fuel at very high efficiencies to reduce emissions of both carbon dioxide and other pollutants associated with combustion. Cogeneration is the simultaneous production of heat and electricity at, or close to, the point of use. It utilizes the heat that is inevitably produced in electricity generation from fuels to feed heating/cooling systems for buildings or directly in industrial process [Saunier and Mohanty, 1996]. By making use of this heat, which is conventional electricity only generation is the most efficient way of turning fuels into useful forms of energy. Cogeneration's high efficiency typically 85% or more, compared to 35-50% for conventional power generation- leads to its three main benefits: lower energy cost to users, [Mohanty 1998]. Reduced use of fuel, reduced emissions of polluting gases. Since the power produced by an industrial cogeneration system becomes a by-product of the process, the incremental energy may be used as a source of captive supply or even wheeled-in to export energy to the grid [Spinks 1995 and Green 1998].

ENERGY CLASS OF THE PLANT

The pharmaceutical industry requires both electrical and thermal energy. Electricity to the factory is supplied from the national grid and natural gas is used to generate steam in a low pressure boiler, which is mainly consumed for processing. Energy counts about 38% of the production cost of the industry [A study report on Cogeneration in industrial and commercial sectors in Bangladesh, 1998]. Energy utilization in machinery's can be economized for better efficiency and for low production cost. The industry operates 24 hrs/day and about 340 days a year.

Electricity consumption

Analysis of the monthly electricity consumption by the 1999 is shown in Fig. 1.

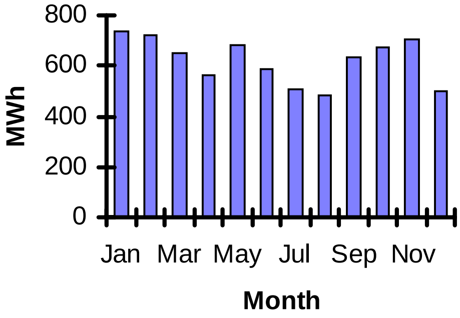

Fig 1 Monthly electricity consumption

Max. electricity consumption (Jan) : 740 MWh
Min. electricity consumption (Aug) : 480 MWh
Maximum electricity demand : 875 kW
Minimum electricity demand : 1,100 kW
Total electricity consumption in 1997: 7,433 MWh

Steam consumption

Analysis of the monthly steam consumption by the year 1999 is shown in Fig. 2.

Maximum steam consumption (Jun): 3,872 Tons
= 5,563 kg/hr
Minimum steam consumption (Jul) : 2,366 Tons
= 3,400 kg/hr
Total steam consumption in 1997 : 9,868 Tons

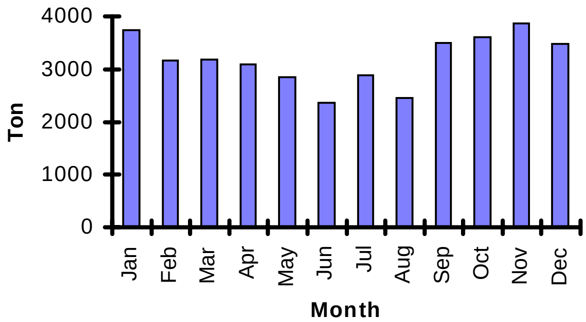

Fig. 2 Monthly steam consumption

Power to heat ratio

Analysis of the power to heat ratio by the year 1999 is shown is in Fig. 3

Maximum power to heat ratio (Jun): 0.35
Minimum power to heat ratio (Dec): 0.27
Average power to heat ratio : 0.31

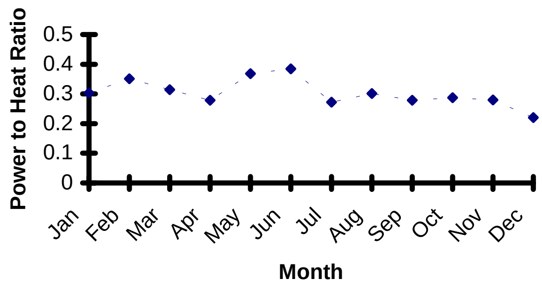

Fig. 3 Monthly power to heat ratio

ASSUMPTIONS USED IN FEASIBILITY STUDY

Assumptions used in pre feasibility study in the spreadsheet analysis are given in Table 1.

Table 1: Assumption used in pre-feasibility study

Exchange rate	Taka/US$	57
Tax rate	%/Year	35
Service life of the cogeneration plant	Year	15
Purchased price of electricity	Taka/kWh	3.6
Buy-back rate	%	80
Fuel price escalation rate	%	5-13
Electricity price escalation rate	%	6-13
Stand by rate	Taka/kW	80
Purchased cost of fuel (natural gas)	Taka/cubic meter	1.68

Assumed installation cost of a CHP plant:

For a steam turbine : US$ 1200/kW
for a gas turbine : US$ 1000/kW
for a reciprocating engine : US$ 900/kW

The net present value (NPV) of cogeneration plant has been estimated as follows:

$$NPV = (CF)(AF)-(I)$$

$$AF = \frac{(1+i)^n - 1}{i(1+i)^n}$$

where,
CF = Cash flow for specific year
AF = Annuity factor
i = Discount rate
n = Predicted economic life of the plant
I = Investment
The NPV estimates the gain or loss resulting from the proposed investment. Therefore if NPV is positive, the investment should be made become the relevant revenues exceed the financing cost. If NPV is negative, the plant is not proposable.

METHODOLOGY

Data on base electricity demand, steam demand, annual electricity consumption, annual thermal energy requirement were the initial inputs to the spreadsheet analysis. The spreadsheet of its own estimate the related parameters required for cogeneration analysis.

SUMMARY OF THE RESULTS

The steam turbine, reciprocating engine and gas turbine options with thermal match and power match results are shown in a computer print out of the spreadsheet analysis in a Table 2. The results in the table also shows the internal rate of return on net investment for each option. Lastly three alternatives were considered for sensitivity analysis.

DISCUSSIONS

The steam turbine option does not seem: (i) with steam turbine thermal match (STTM), less than 21% of the power requirement is generated (ii) with steam turbine power match (STPM), 89% excess power and 172% excess heat is generated. This should not be considered for sensitivity study.

With the reciprocating engine thermal match (RETM) option, 320% excess power is generated. The project profitability will depend on the buy-back rate. This may not be a good option as the main purpose is not to earn from electricity sale. Reciprocating engine power match (REPM) option seems as almost all power need can be met though heat generated is less than 78% of the requirement. There is a need to have auxiliary boiler.

With gas turbine thermal match (GTTM) option, about 87% excess electricity is generated which not be acceptable. Gas turbine power match (GTPM) option is also good as heat deficit is around 62% which can be met by auxiliary natural gas firing in the recovery boiler and the total installation cost of GTPM is 51% less than GTTM.

Therefore, sensitivity analysis may be limited to REPM and GTPM options.

Table 2: Summary of results

Major Parameters	Steam turbine		Gas engine		Gas turbine	
	Thermal match	Power match	Thermal match	Power match	Thermal match	Power match
Installed power (kW)	238	875	4157	875	1873	875
Fuel consumption (TJ/Yr)	88.9	326.1	382.5	88.5	205.7	97.7
Electricity generated (MWh)	1849	6783	32226	6783	14284	6783
Heat generated (TJ/yr)	73	267.8	73	15.4	73	34.7
Excess/deficit(-) power (MWh/yr)	-5548	-650	24793	-650	6851	-650
Excess/deficit(-) heat (TJ/yr)	-16.3	151.8	-16.3	-73.9	-16.3	-54.6
Equipment power-to-heat ratio	0.091	0.09	1.87	1.87	0.8	0.8
Total investment (million Taka)	13.7	50.4	179.59	37.8	88.44	42
Net present value (million Taka)	16.94	20.36	234.12	68.42	110.84	64.59
IRR (%)	33.2	21.3	34.1	40.8	33.4	37.2

SENSITIVITY ANALYSIS

The sensitivity analysis carried out to see the impacts of the increase in the investment, fuel and electricity price escalation was limited to STPM, REPM and GTPM options. These are shown in Figs. 4, 5, and 6.

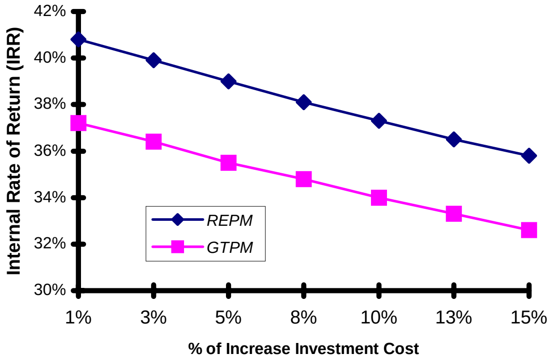

Fig. 4 Internal rate of return vs. investment cost

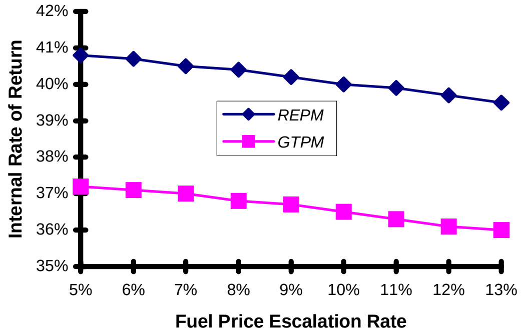

Fig. 2 Internal rate of return vs. fuel price escalation rate

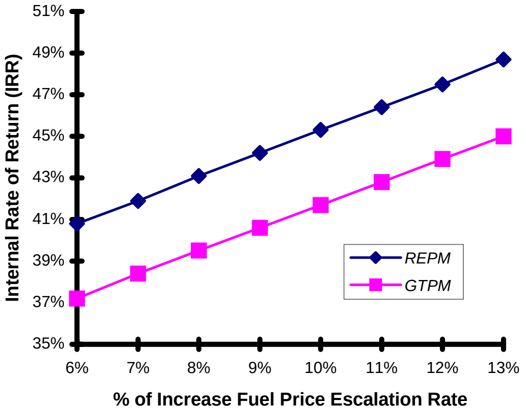

Fig. 6 Internal rate of return vs. increase fuel price

CONCLUSION

From the sensitivity analysis the potential cogeneration alternatives of the pharmaceutical industry, the reciprocating engine power match option meeting power requirement of 875 kW to be the most suitable co-generation system. It represents an initial investment of 37.8 million Taka and leads to an internal rate of return of 41.8%.

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