Viability of Biomass-fuelled Cogeneration Plants in Paper Mills

Efficiency improvements in paper mills not only conserve scarce fuel but also reduce CO_2 emissions in the atmosphere. In this case study, the efficiency investment pattern shows very high profits. Through various financial analysis tools, such as DSCR, payback, IRR, the author justifies the implementation of the project. Besides very attractive rates of return, project financing lies within the tolerable limits of risk

There are more than 400 paper mills in India, with the concentration being higher in the eastern region. The Current total capacity of these plants is about 5.0 million tons per annum (MTPA).

Paper plants need both high-and low-pressure steam to process paper. Steam is primarily used in digesters and pulp making equipment, where the quality of the end product depends highly on the quality of steam being supplied. Most plants require high-pressure steam from 5 kg/cm^2 (a) to 9 kg/cm^2 (a) and low-pressure steam from 2 kg/cm^2 (a) to 4 kg/cm^2 (a), according to type of process and capacity of the plant.

Process steam is usually supplied from a low-pressure boiler. The most common boiler used in paper plants has a pressure rating of 10-12 kg/cm^2 (a), whose outlet steam pressure is further reduced in a pressure regulating and desuperheating station (PRDS), according to the process steam requirement.

A paper plant's requirement of electrical energy is relatively high. A typical paper plant demands 0.85 – 1.05 kWh per kg of paper produced depending upon the capacity of the plant and the manufacturing process.

Cogeneration Plants

The use of cogeneration in a paper plant is an old concept. Most paper plants use fossil fuels such as coal, furnace oil, etc, to generate steam in low-pressure boilers in which cogeneration is not adopted. But where the system exists, the steam is produced in a high-pressure boiler and routed through a high-pressure steam turbine. The bled steam from the interstage turbine is then used. After single or double extraction of steam from the turbine, the remaining is passed through a condenser for recycling into the thermal power plant system.

For meeting its process steam requirements, a high-pressure boiler of usually 62.0 kg/cm^2 (a) or higher is ideal. The steam thus generated is expanded in the steam turbine to generate electricity. But for uninterrupted and quality supply of electric power along with regular generation of steam, a captive power plant is preferable to grid supply or diesel generating sets. Captive power plants will also help counter ever increasing electricity tariffs or diesel and furnace oil prices.

In small and medium-sized paper plants, the scope for using biomass fuels such as rice husk and bagasse is being examined. These fuels can help in both raising the overall thermal cycle efficiency and lowering CO_2 emission levels.

Fuel for the Power Plant

Depending upon the geographic location of the plant and fuel availability, the following fuels may be used:

- **Coal**: If the power plant capacity is more than 10MW, coal may be the optimum fuel.
- **Biomass-based fuel**: If the power plants are of 8-10 MW capacity, and depending upon the availability, rice husk, bagasse or any other non-conventional agro-based fuel such as saw dust, groundnut shell, etc, or two or more fuels may be used in mix.

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In this particular case, a paper processing plant of 3 MW has been considered, requiring a continuous supply of 26,000 tpa of rice husk. The plant sometimes uses bagasse, which is also a suitable fuel. Hence, a mixture of 70 per cent rice husk and 30 per cent bagasse will be the most economic solution.

Replacement of Existing Boiler

The following factors need to be considered while replacing the existing low-pressure boiler with the new high-pressure boiler:

- Steam pressure requirement of the paper plant
- Total capacity of the steam required for the paper plant
- Power requirement of the plant and power to be exported to the grid
- Cycle configuration of the cogeneration plant
- Market availability and lead-time of the existing range of boilers

The total existing steam requirement for the plant is around 14 tph in full capacity of 40 tpd paper production. The existing boiler had a thermal efficiency of 65 per cent. The total fuel requirement before implementation of the energy efficiency measures was 7,245 tpa bagasse and 16,905 tpa rice husk. After incorporating the high-pressure boiler of 65 kg/cm^2 (a), with outlet steam temperature at 485 ^{o}C and capacity of 26 tph, the thermal efficiency of the boiler achieved was up to 82 per cent ($\pm$ 2 per cent).

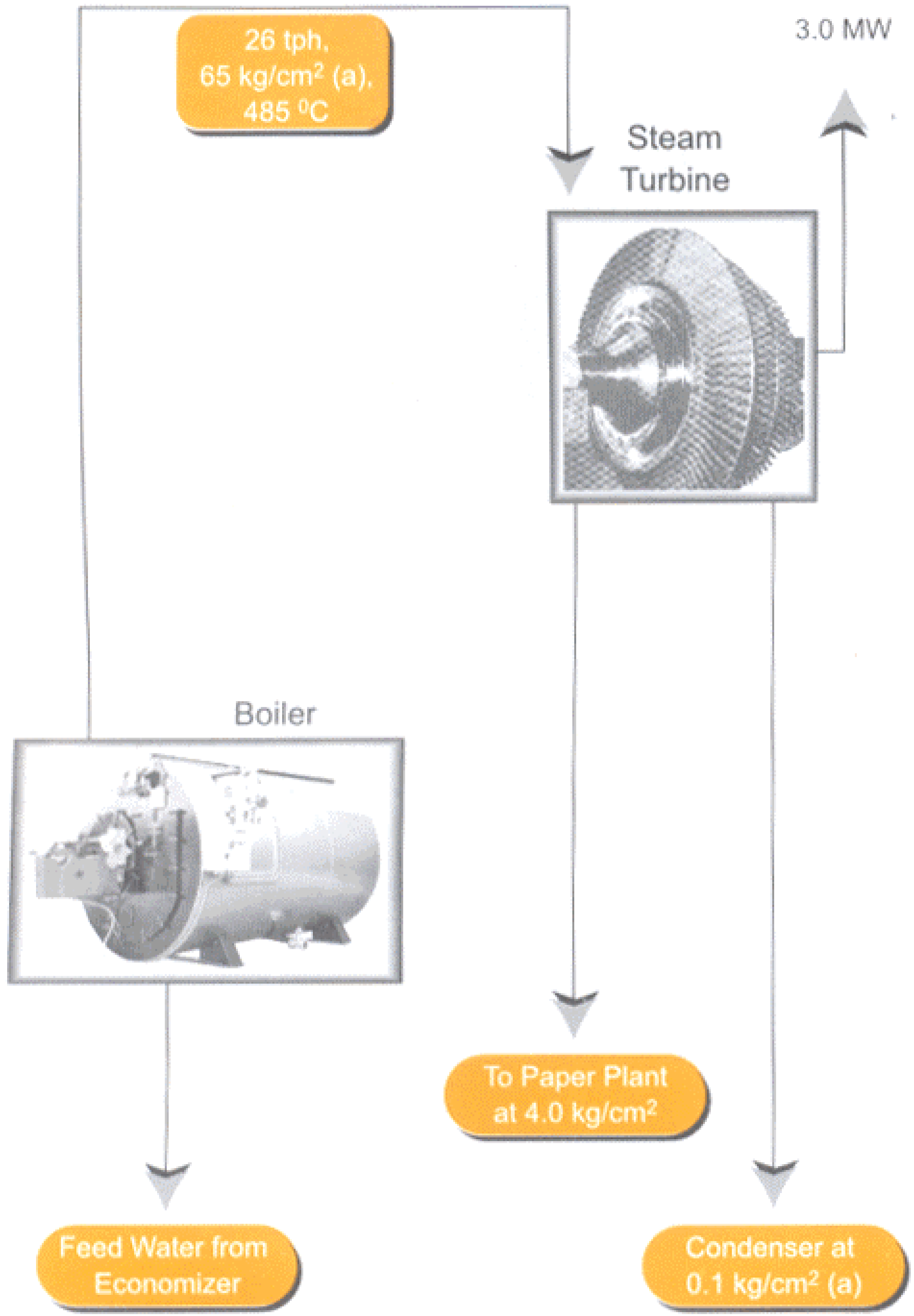
Table: 1

	Steam quantity (TPH)	Electricity Generated (kWH per year)	Rice Husk Consumed (Tons per year)	Rice Husk Saving (Tons per year)
Before implementation of the project	14	89.896 x 10^5	27,546	Nil
	14	144 x 10^5	32,498.67	Nil
After Implementation of the project	18	144 x 10^5	26,351.65	6,147.02

Power from Steam Turbine

The plant is currently dependent on 6,080 kVA diesel generators for 8,989,600 kWh power per annum. Furnace oil is used in these generators. The proposed installation of a 3 MW TG based power plat will replace furnace oil with rice husk (70%) and bagasse (30 per cent). About 26,352 tpa of rice husk will be consumed. The boiler steam capacity has been augmented from 14 tph to 26 tph owing to the process demand. See data given in Table 1 on the left.

The statistics in the table shows that there is potential of high saving in the consumption of rice husk in the cogeneration project. The net saving in the rice husk for generation of 144 x 10^5 kWh per year along with 18 tph of steam would be 6,147 tons per year. Further, there will be a saving in the use of furnace oil, which accounts to 4,235,294.20 per year.


26 tph,
65 kg/cm2 (a),
485 0C
3.0 MW
Steam
Turbine
Boiler
To Paper Plant
at 4.0 kg/cm2
Feed Water from
Economizer
Condenser at
0.1 kg/cm2 (a)

Financial Analysis of the Project

▪ Total project cost	Rs. 820 lakh
• Cost of additional land required for plant	Rs. 12.0 lakh
• Building and civil works	Rs. 52.0 lakh
• Plant and machinery	Rs. 689.0 lakh
• Preliminary & pre-operative expenses	Rs. 67.0 lakh
▪ Cost per kW (installation)	Rs. 27,300
▪ Average cost per kWh (in a 10-year life span)	Rs.4.55
▪ Steam cost per kg of steam (in a 10 year life span)	Rs. 0.46
▪ Considering stem, the average kWh cost (in a 10-year life span)	Rs. 1.81

Project Financing and its Analysis

In the proposed Debt/Equity ratio of 70:30, the parameters given in the box below have been envisaged in the financing scheme. Cash flows under the project and the NPV and IRR analysis are given in the next page.

▪ Loan amount	Rs. 574 lakh
▪ Repayment period	10 years
▪ Moratorium period	2 years
▪ Rate of Interest	12.5% (net, after considering rebate)
▪ Number of Quarterly Installments	40
▪ Equal Quarterly Installment	Rs. 30.604 lakh
▪ Average Earning per Share	Rs. 14.87
▪ Net Profit after Tax (Annualised for 10 Yrs.)	Rs.371.70 (per annum)
▪ Debt service coverage ratio	4.359 (with moratorium) 3.073 (without moratorium)
▪ Payback period	1 year and 8 months

NPV Analysis

$$NPV = -P_0 + \Sigma \left[(\text{Net Cash Flow}) / (1+i)^n \right]$$
$$n = 1$$

Where, NPV = Net Present Value

P_0 = Total Investment in the Project

i = Effective Interest Rate = 12.5%

n = Number of Years

Also,

$$PV = a^{o}{}^{10}_{n=1} \left[(\text{Net Cash Flow}) / (1+i)^n \right]$$

PV = Present Value

IRR Analysis

$$PV = \sum_{n=1}^{10} [\text{Net Cash Flow})/ (1+i)^n]$$

NPV = - P_0 + PV

Also,

$$NPV = -P_0 + \frac{C_1}{(1+IRR)^1} + \frac{C_2}{(1+IRR)^2} + \frac{C_3}{(1+IRR)^3} + \frac{C_4}{(1+IRR)^4} + \frac{C_5}{(1+IRR)^5} + \frac{C_6}{(1+IRR)^6} + \frac{C_7}{(1+IRR)^7} + \frac{C_8}{(1+IRR)^8} + \frac{C_9}{(1+IRR)^9} + \frac{C_{10}}{(1+IRR)^{10}}$$

Where,

P_0 = Investment in the Project = Rs 820 lakh

C_1 ……….C_{10} = Net Cash Flows for respective years

IRR = Internal Rate of Return

$$NPV = -820 + \frac{392.07}{(1+IRR)^1} + \frac{379.37}{(1+IRR)^2} + \frac{389.95}{(1+IRR)^3} + \frac{320.05}{(1+IRR)^4} + \frac{342.00}{(1+IRR)^5} + \frac{366.16}{(1+IRR)^6} + \frac{390.60}{(1+IRR)^7} + \frac{425.40}{(1+IRR)^8} + \frac{445.57}{(1+IRR)^9} + \frac{618.89}{(1+IRR)^{10}}$$

By Trial and Error Method

NPV (Rs in lakh)	1,641.20	803.22	382.35	113.00	-62.55
i (in%)	10	20	30	40	50

CASHFLOWS

Year	Cash inflow (Rs. in Lakh)	Cash Outflow (Rs.in lakh)	Net Cashflow (Rs in Lakh)	PV (Rs in Lakh)
1	981.33	589.26	392.07	348.51
2	1,029.5	655.13	374.37	297.12
3	1,080.10	690.17	389.93	273.86
4	1,133.126	813.08	320.05	199.81
5	1,188.89	846.39	342.50	190.06
6	1,247.522	881.36	366.16	180.62
7	1,308.70	918.10	390.60	171.26
8	1,373.07	947.67	425.40	165.80
9	1,440.76	997.19	445.57	154.36
10	1,511.69	1,039.65	618.89	190.58

NPV = [-820+ (348.51+297.12+273.86+199.81+190.06+180.62+171.26+165.80+154.36+190.58)]

NPV = +Rs 1,351.98 lakh

Since NPV of the project is a positive value, the project is viable.

In view of the attractive payback period of 1 year and 8 months, and an excellent DSCR and the NPV analysis also being positive and an IRR value of 46 per cent, the project is viable as far as the financial performance is concerned.

Conclusion

Efficiency improvement efforts in the plant not only reduce the use of high scarce fuel but also reduce CO_2 emissions in the atmosphere due to the overall improvement in the thermal cycle. The investment pattern of the project shows a very high profit in response as per its return. All the financial analysis efforts such as DSCR analysis, payback period, IRR analysis, etc, justified that the implementation of this particular type of project has very attractive rate of return and the risk involved in the project financing lies within the tolerable limits.

Reference book:
The Bulletin on Energy Efficiency
February 2002,
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