ECONOMICS OF COGENERATION IN MILK PLANT FOR ENHANCED ENERGY EFFICIENCY AND REDUCED GHG EMISSIONS

ABSTRACT

The importance of energy as vital element in economic development as well as in any strategy for improving the living standard of human beings is well established. Cogeneration also called combined heat and power (CHP) system is an efficient way of energy production & utilization, which simultaneously produce heat & electricity. These are designed and can be installed in industrial, institutional or residential premises to supply all heating & electricity demands of a facility and increase the economic profitability of existing facility. Use of biomass as boiler fuel generates clean energy, steam and electricity and further contributes towards sustainable development by optimizing utilization of renewable energy source & lowering the carbon footprint.

In this paper, carbon mitigation potential and financial benefit of cogeneration systems has been studied in comparison to conventional system of individual generation system of steam, electricity. Proposed model has been employed in a milk processing industries situated in Patiala district of Punjab state in India (Milkfood Limited). Considering the electricity and heat demand of the milk processing plant and characteristics of existing system; optimum cogeneration capacity and operation strategy has been defined.

Keywords: *Cogeneration, Energy, Biomass, Sustainable, Carbon*

1. Introduction:

Cogeneration or combined heat and power (CHP) is onsite generation of heat & electricity from same fuel input and thus increases the efficiency and decrease total fuel consumption and related GHG emissions by generating both electricity and useful heat from the same fuel input. Cogeneration have come to attention with their advantages of higher efficiency, less consumption of fuel, and consequent decrease in CO_2 and other emissions (Temir et al., 2004). As a result of CHP application, the efficiency of energy production can be increased from current levels that vary from 35% to 55% in conventional power plants, to over 90% in the CHP system (Rosen and Dincer, 2005). Coupling co-generation and renewable makes a very strong proposition since it leads to supply of both low-carbon electricity and low-carbon heat. In the case of co-generation plants fuelled by renewable energy sources, the low-carbon benefits of the heat are obvious since they derive from the renewable nature of the fuel. Energy efficiency and renewable are both important if a sustainable future is to be realized. This is well illustrated in Energy Technology Perspectives 2010 (ETP 2010). When biomass is used as the boiler fuel it further adds into decreasing the carbon footprint of the organization as carbon dioxide emission from biomass combustion is considered as neutral and its not counted in the GHG inventory (Tarnawski, 2004). Energy efficiency and environmental impact are inversely proportional to each other, since for the same services or products better resource utilization will minimize the pollution, hence reduce energy resource depletion. In an efficient system, energy input requirement are reduced per unit output and pollutants are generated correspondingly reduced (Dincer, 2004). The economics of the options are analyzed in terms of simple payback time (SPB) to assess the overall return on the retrofit installation of the required equipment.

2. DESCRIPTION OF THE COGENERATION STUDIED:

2.1 General description:

This study was conducted at Milkfood Limited which was set up in the year 1973 with the first Plant at Bahadurgarh, on the Rajpura Patiala Road in the State of Punjab having present milk processing capacity of plant is 1500 MT per day. The company manufactures pure ghee, skimmed milk powder, whole milk powder, and dairy whitener.

Milk plant considered for the purpose of this work, as an energy-producing facility delivering steam from different energy carriers. These are consumption of fossil fuel as boiler fuel for steam generation which is the requirement of various milk processing units and electricity import for running & operation of electrical equipments. Earlier coal (fossil fuel) was being used as boiler fuels while electricity is imported from grid.

2.2 Description of the system studied:

Milkfood Ltd has thermal requirement of 268 TJ & 1200kW of connected load. Three type of possible scenario is studied for the plant with different combination of fuel type & electricity import from grid. Possible scenarios for the plant energy requirement are as follow:

Case I: Thermal demand met by coal based boiler and Electricity imported from grid

The electric power demand of Milkfood Limited was met by the grid supply and the steam demand was met by coal fired boilers.

Case II: Thermal demand met by rice husk based boiler and Electricity imported from grid

The electric power demand of Milkfood Limited was met by the grid supply and the steam demand was met by rice husk fired boilers.

Case III: Cogeneration

This option consists of a steam turbine and a condensing unit installed. The cogeneration in milk plant is not new, though not yet common practice in India. The turbine is normally fed by HP steam and delivers MP and LP steam (extraction-operation mode) or condensate (condensing mode).

2.3 Process description and operation conditions for cogeneration:

Boiler of this cogeneration plant generates 14 TPH (tones per hour) of steam with the outlet parameters i.e. pressure 45 kg/cm^2 (g), and temperature as 420 ^{0}C. The part of the steam generated in the boiler i.e. 1.2 TPH at 17kg/cm^2, 275 ^{0}C is fed directly to the process and the rest 12.8 TPH is fed to a back pressure turbine-generator. The bleed steam flow from the turbine is at 17 kg/cm^2, 3.1 TPH, 240^{0}C and the exhaust steam flow from the turbine is at 4 kg/cm^2, 9.7 TPH, 170^{0}C.

The boiler is provided with dust collection system for reducing the outlet flue gas dust concentration levels. The boiler operates with balanced draft conditions, with the help of forced and induced draft fans. There is common de-aerator which de-aerates the feed water and supplies the feed water to the feed water pumps at about 105^0 C.

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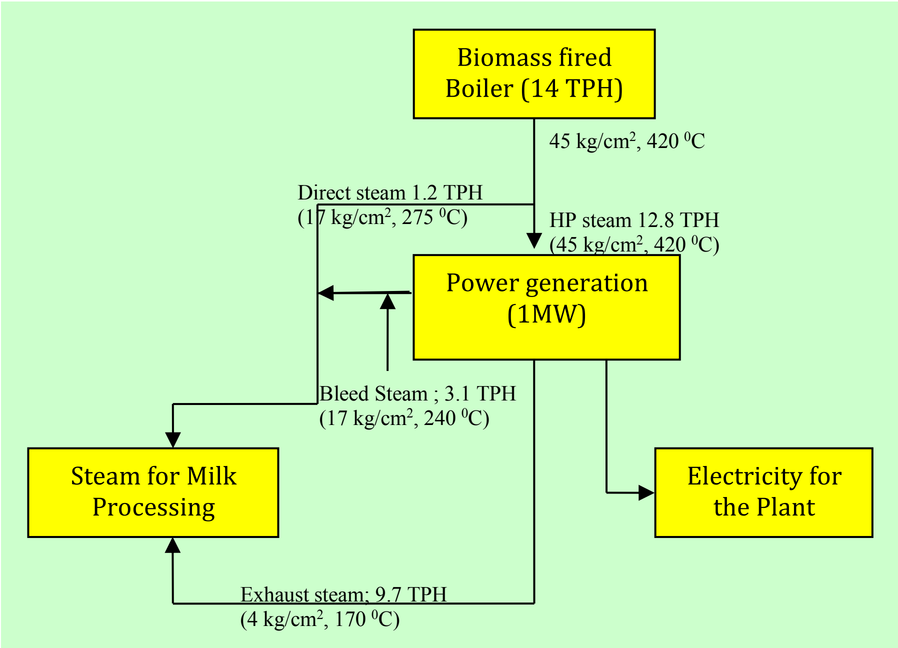

3. ECONOMIC EVALUATION OF THE COGENERATION SYSTEM

Simple payback period is used as economic indicator for cost analysis of discussed scenario. It must be noted that this study considered only the incremental cost of the system. Therefore the investment only consists of the retrofit cost i.e. retrofitting of coal based boiler to rice husk boiler in the scenario II while in the scenario III, cogeneration plant cost has been considered for the financial assessment. Running cost for the different scenario is the cost of coal & electricity in scenario I while for scenario II it is the cost of rice husk used in the boiler and electricity imported. In scenario III which has captive cogeneration plant generating for in-house electricity and thermal requirement.

3.1 Simple Payback Time

The economic calculation was performed on the basis investment (capital cost) & running cost. Simple payback period is the time required for recovery of an expenditure on a project which is calculated by dividing the project investment by the expected saving (profits) per unit time (usually in years):

$$PB = I / A$$

Where PB is simple payback in years, I is the investment incurred and A is the profit or saving per unit time. Simple payback emphasizes the return on investment and its is first order selection criteria for the selection of project. The results are summarized in Table below. All financial information is given in Indian Rupee.

Simple payback period for different scenario:

	Case I **Coal based Boiler**	**Case II** **Rice Husk Based Boiler**	**Case III** **Cogeneration**
Thermal Requirement (kJ/Year)	2,68,19,88,92,390	2,68,19,88,92,390	3,98,94,79,20,000
Capital Cost	0	12,00,000	3,00,00,000
Fuel Cost (Rs/Year)	4,45,70,745	5,33,92,039	7,94,21,070
Electricity Cost (Rs/Year)	4,73,04,000	4,73,04,000	0
Yearly Running Cost	9,18,74,746	10,06,96,039	7,94,21,070
Simple Payback Period	-	NA	2.40

4. GHG EMISSION COMPARISON OF THE SYSTEM

Generation of electricity for captive consumption using rice husk as fuel in Milkfood limited's cogeneration plant will lead to mitigation of GHG emissions from the fossil fuel based plants, which supply steam and power to Milkfood limited. In order to monitor the mitigation of GHG due to at the project activity at Milkfood limited, the total electricity produced, total steam generated for process and auxiliary consumption need to be measured.

$$E_{Electrical,CO2} = EG \times EF_{Grid}$$

Where E is emission due to use of electricity, EG is unit of electricity generated by the cogeneration plant while EF is the grid emission factor at combined margin taken from the Central Electricity Authority, version 05 & its value id 0.84 tCO_2e/MWh.

For steam/ heat produced using fossil fuels the baseline emissions are calculated as follows

$$E_{Thermal,CO2} = (EG_{Thermal} / \eta) \times EF$$

Where E is emission due to combustion of fuel for steam/heat application, EG is net quantity of heat supplied, EF is the emission factor per unit of the energy of the fuel which has been sourced from reliable local or national data if available, otherwise IPCC default emission factor can be used, η is the efficiency of the plant.

5. RESULTS

ELECTRICITY	
Emission due Electricity 1 MW, PLF = 0.9, Working Hour = 8760, Grid Emission Factor = 0.84	= 1x 0.9 x 8760 x 0.84 = 6,622 tCO_2e
STEAM	
At High pressure (after conjunction point of direct and bleed Steam)	Total annual energy of the steam drawn at HP = 84.62 Terra Joule/Year
At low pressure (Exhaust Steam)	Total annual energy of the steam drawn at LP = 183.57 Terra Joule/Year
Emissions due to steam η_{Boiler} = 82%, Coal EF = 95.81 tCO_2e/TJ	31,336 tCO_2e
Total Emission due to heat & electricity	37,958 tCO_2e

Emission reduction for different scenario:

	Case I Coal based Boiler	Case II Rice Husk Based Boiler	Case III Cogeneration
Emission Reduction (tCO_2e)	0	31,336	37,958

6. CONCLUSION

The environmental and economic impacts of the three technological options, coal based boiler, rice husk based boiler & rice husk based cogeneration system, have been analyzed. The simple payback period of all the options have been calculated. The results suggest economic viability for cogeneration options is best among the discussed cases. The SPB is 2.4 year for a cogeneration system supplying heat & electricity for captive use. In addition to this is all helping in emission reduction of 37, 958 t of carbon dioxide equivalent.

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