Power Generation in Process Industies

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Today energy is one of the basic needs of mankind in addition to air, water and food. Food is the source of energy for oneself. Civilization and abnormal growth of population has put tremendous pressure on energy sources. Natural energy sources are fast depleting. Emissions of greenhouse gases are on the threshold limit. Environment has been damaged so badly, that our future generation is at threat of starving for energy. Eco system has been totally disturbed. Global warming upsets sea level due to melting of glaciers. United Nations Organization started working on the protection of environment way back in 1992. Kyoto protocol signed in 1997. United Nations Framework on Climate Change started monitoring the global phenomena. India has also initiated action in this direction by establishing Bureau of Energy Efficiency (BEE) as the national level nodal agency to oversee and monitor the energy consumption in all walks of life. Govt. of India promulgated Energy Conservation Act 2001 to encourage the energy conservation and energy efficiency. Pulp and Paper industry sector, being one among the bulk energy consumer can contribute in the massive task of preserving energy and environment by optimizing their energy efficiency by co-generation and energy efficiency practices.

INTRODUCTION

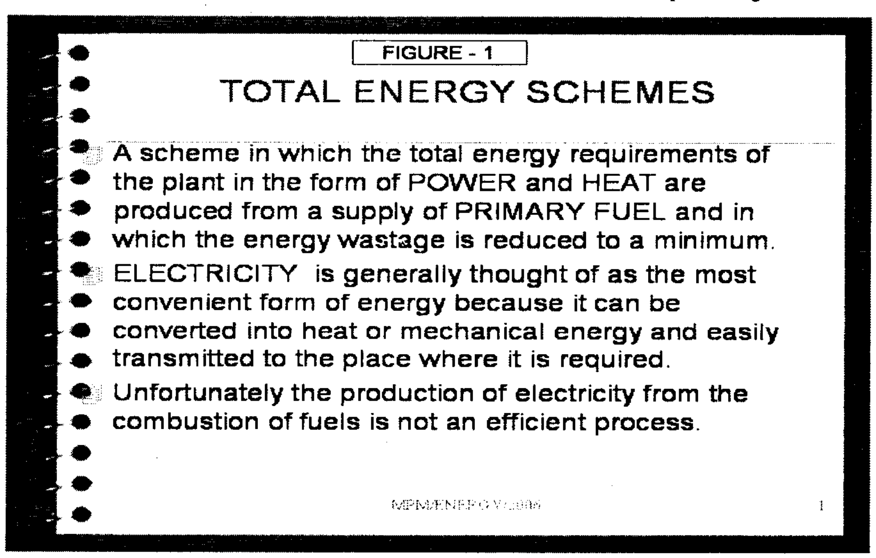
It is a well-known fact that energy in the form of heat and electricity is a prime requirement in any manufacturing industry. Similarly, pulp and paper industry is one of the energy intensive process industries. In pulp and paper manufacturing as much as 25% of the manufacturing cost is towards energy in the form of power and fuel.

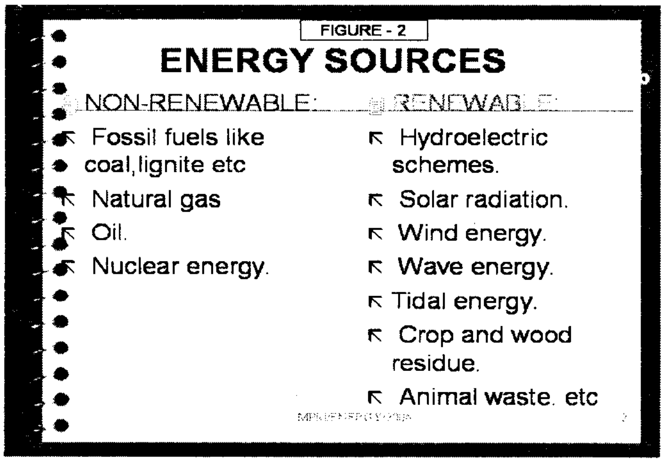
Energy Conservation Act 2001 promulgated w.e.f. 1st March,2002. Bureau of Energy Efficiency (BEE) a nodal agency under the Ministry of Power Government of India has been established to promote and monitor energy consumption and conservation activities across the wide cross section of Indian Industry. Among the identified designated energy consumers, pulp and paper industry is one with a substantial energy saving potential to the extent of 25%.

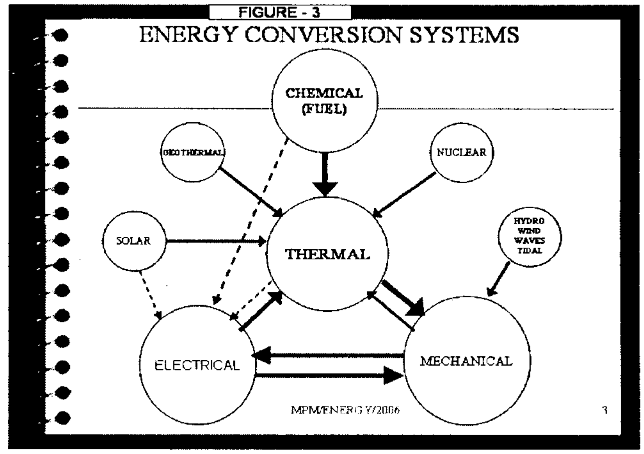
The Mysore Paper Mills Ltd., Paper Post Town, Bhadravathi - 577302 Karnataka

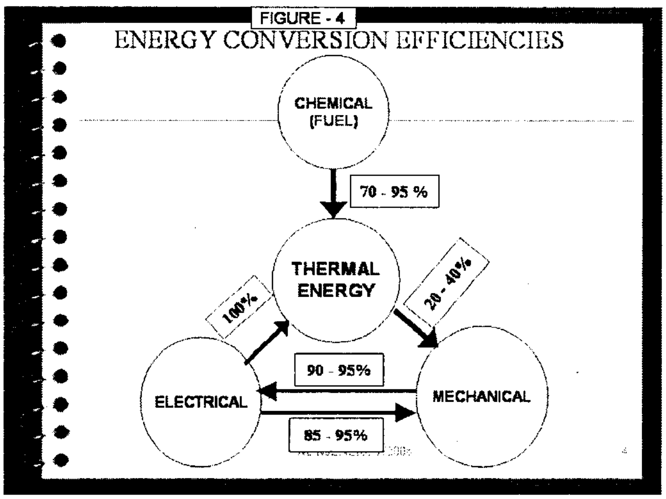
All these years, it was general practice in most of the pulp and paper industry to buy electricity from state or central electricity boards and generate thermal energy using low pressure boilers. Slowly industries understood importance of co-generation of electricity and heat together. This concept has the highest efficiency in overall system.

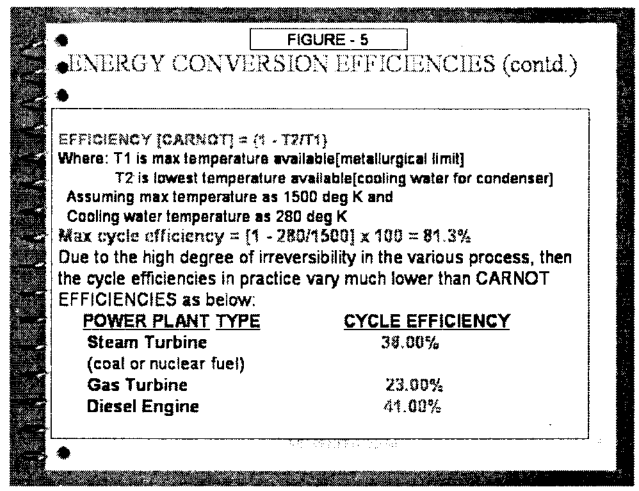
It is a known fact that combustion is a process where carbon, hydrogen and sulfur from any fuel combine with oxygen in an elevated temperature of around 900 to 1500^0 C depending on the type of combustor. Heat is liberated in the process. This high temperature energy from the combustion products transferred to the process or heat conveying medium i.e water in case of boilers, which is a safe and universally used medium as steam. High level energy from combustion products transferred to steam at different pressure and temperature in boilers. Steam is used in power generation









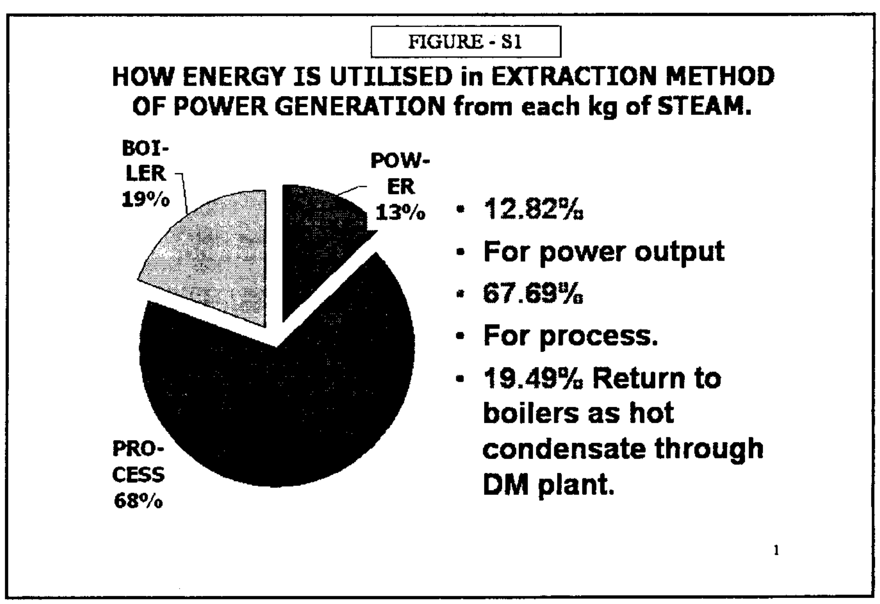


and process applications. Total energy schemes, sources of energy, conversion methods and efficiencies can be seen from figures 1 to 5.

In the past there was a limitation on metal temperature of the boiler components, which are subjected to internal pressure. Predominantly low and medium pressure boilers were being used, where pressure and temperature were in the range of 12 to 40 kg/cm^2 and 200 to 400^{0}C. Even though combustion takes place at around 900 to 1500^{0}C, output temperature of steam from the boiler used to be in the range of 200 to 400^{0}C. Once the combustion product temperature is brought down, it can not be raised again without the external support of energy.

'Steam is universally used media for conveying heat from fuel to power generation and process application. Steam mainly consists of three components of heat as below.

1. Sensible heat (in liquid form)
2. Latent heat (in vapor form)
3. Super heat (in gaseous form)



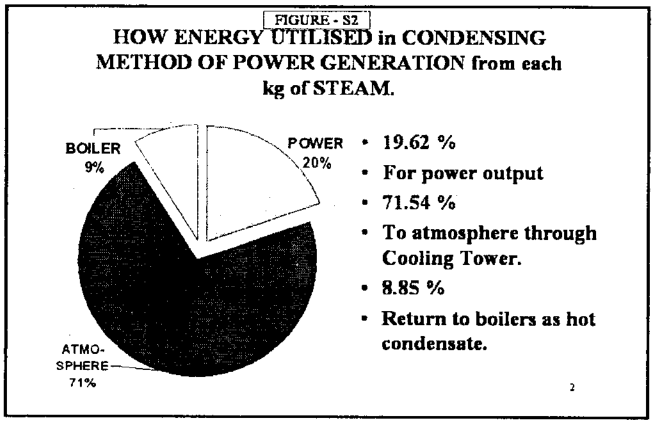


FIGURE - S2
HOW ENERGY UTILISED in CONDENSING METHOD OF POWER GENERATION from each kg of STEAM.
BOILER 9%
POWER 20%
ATMO-SPHERE 71%
• 19.62 %
• For power output
• 71.54 %
• To atmosphere through Cooling Tower.
• 8.85 %
• Return to boilers as hot condensate.
2

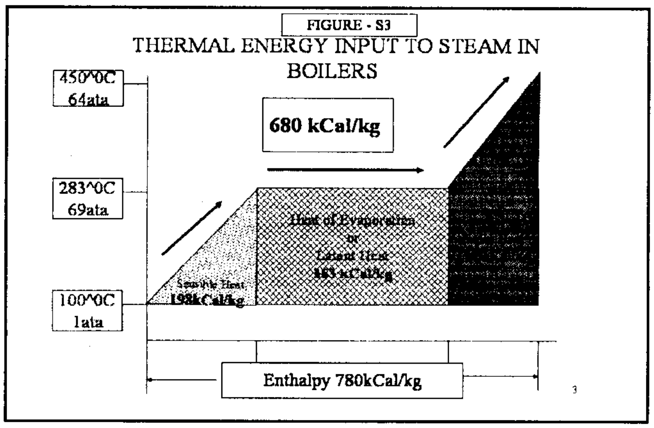


FIGURE - S3
THERMAL ENERGY INPUT TO STEAM IN BOILERS
450^0C 64ata
283^0C 69ata
100^0C 1ata
680 kCal/kg
Heat of Evaporation or Latent Heat
198kCal/kg
Enthalpy 780kCal/kg
3

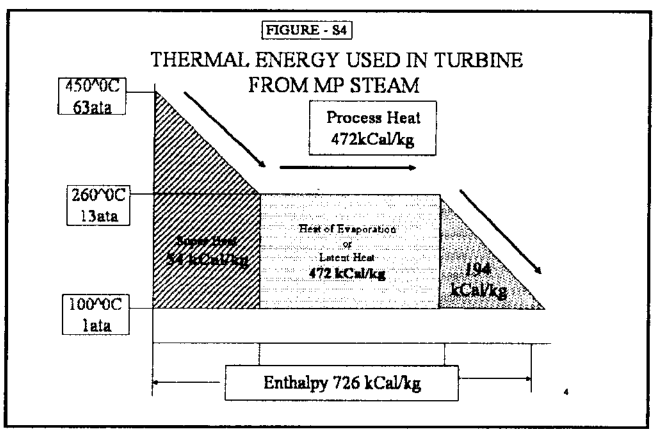


FIGURE - S4
THERMAL ENERGY USED IN TURBINE FROM MP STEAM
450^0C 63ata
260^0C 13ata
100^0C 1ata
Process Heat 472kCal/kg
Super Heat 54 kCal/kg
Heat of Evaporation or Latent Heat 472 kCal/kg
194 kCal/kg
Enthalpy 726 kCal/kg
4

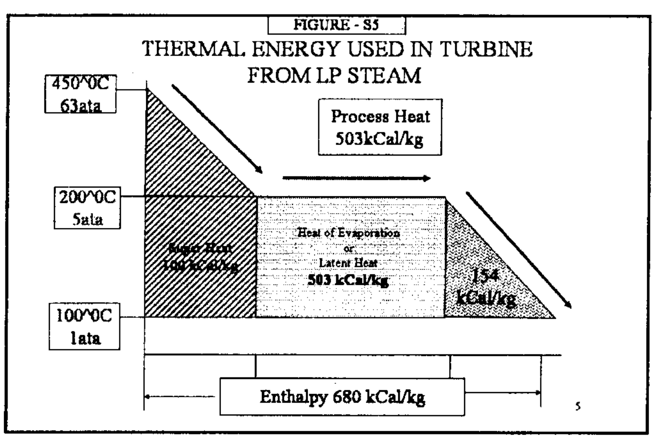


FIGURE - S5
THERMAL ENERGY USED IN TURBINE FROM LP STEAM
450^0C 63ata
200^0C 5ata
100^0C 1ata
Process Heat 503kCal/kg
Super Heat 100 kCal/kg
Heat of Evaporation or Latent Heat 503 kCal/kg
154 kCal/kg
Enthalpy 680 kCal/kg
5

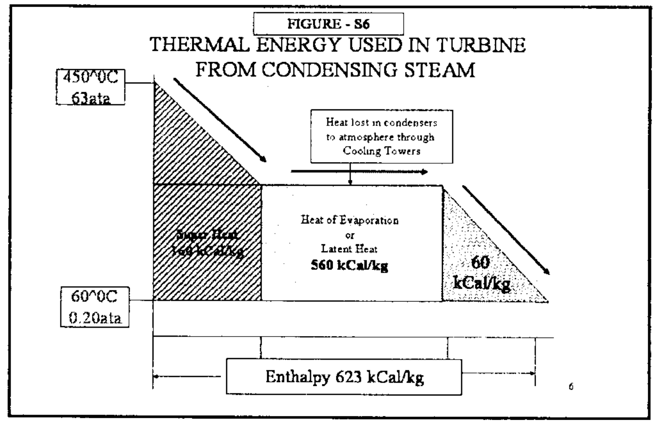


FIGURE - S6
THERMAL ENERGY USED IN TURBINE FROM CONDENSING STEAM
450^0C 63ata
60^0C 0.20ata
Heat lost in condensers to atmosphere through Cooling Towers
Heat of Evaporation or Latent Heat 560 kCal/kg
60 kCal/kg
Enthalpy 623 kCal/kg
6

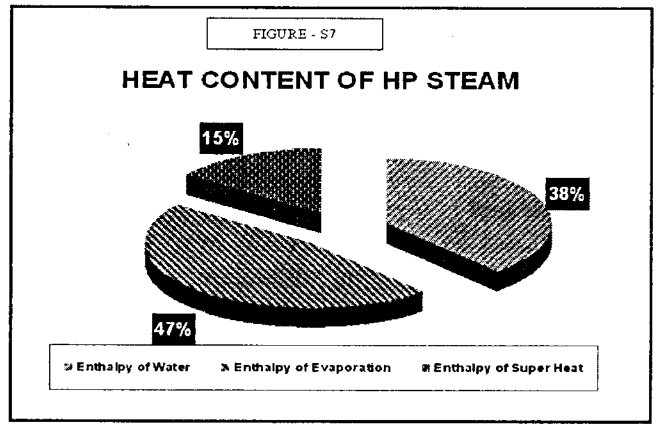


FIGURE - S7
HEAT CONTENT OF HP STEAM
15%
38%
47%
Enthalpy of Water
Enthalpy of Evaporation
Enthalpy of Super Heat

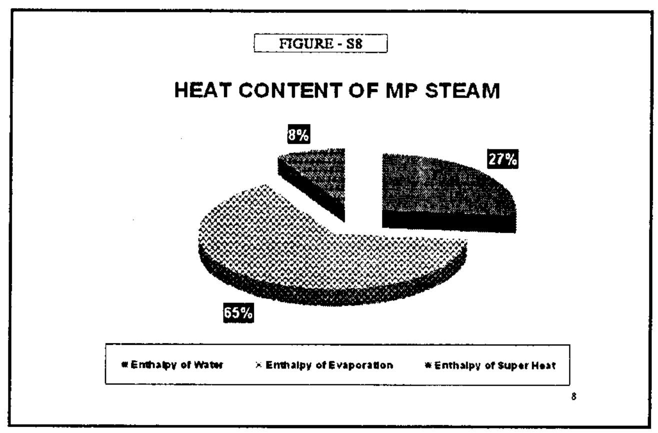


FIGURE - S8
HEAT CONTENT OF MP STEAM
8%
27%
65%
Enthalpy of Water
Enthalpy of Evaporation
Enthalpy of Super Heat
8

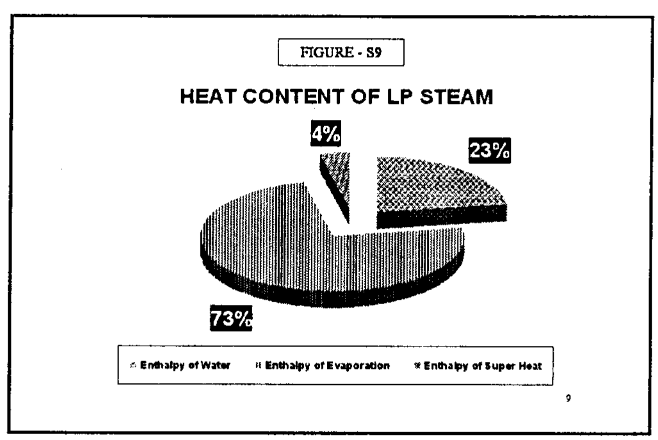
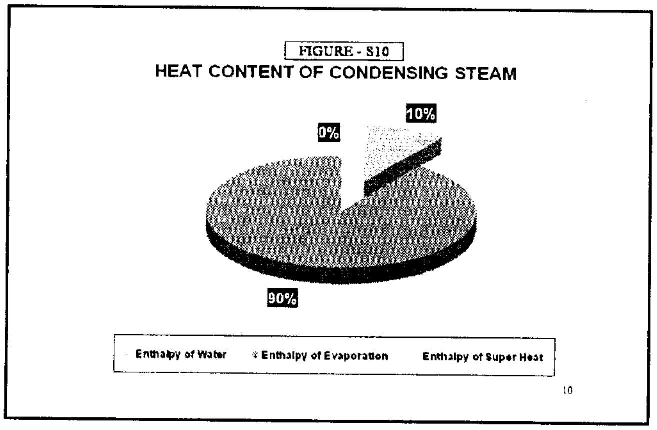
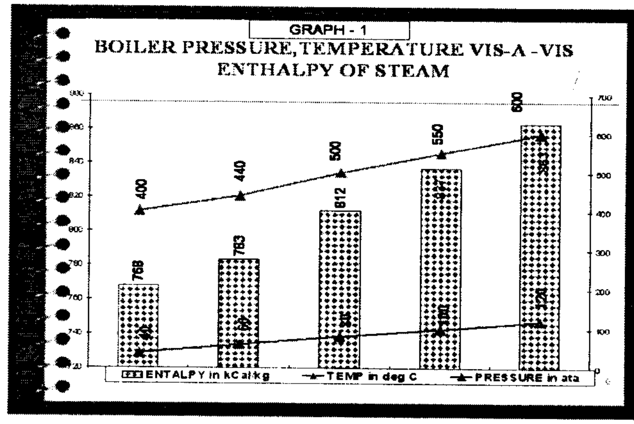


FIGURE - S9
HEAT CONTENT OF LP STEAM
4%
23%
73%
Enthalpy of Water
Enthalpy of Evaporation
Enthalpy of Super Heat
9





In power generation only super heat is utilized in the steam turbines.

Latent heat is the one mainly used at a constant temperature in any drying process.

Sensible heat of water is made use of by reducing the surface pressure on water by flashing steam where low temperature steam can serve the purpose.

It can be seen from the figures S1 to S10 composition of sensible heat, latent heat quantities that varies depending on pressure of steam. Super heat quantity varies with degree of super heat for which steam is heated over and above saturation temperature at the corresponding pressure. Percentage of heat used for power generation, process application etc. (parameters as applicable to Mysore Paper Mills boilers shown in figures)

With the above phenomena of steam parameters it is more and more beneficial to transform the energy from fuel to power at a higher pressure. Fuel to process at a lower pressure within metallurgical and process permissible limits for pressure parts of boilers and process applications. It can seen from graph 1 to 3 enthalpy variation with pressure, specific steam consumption for power generation by extraction and condensing methods.

Power Generation

Coming to power generation, transmission, distribution and utilization scenario. Most of the thermal power plants produce power with an overall average efficiency of 30 to 35%. Heat rate of a thermal plant is in the range of 2400 to 3000 kCal/kWh. I.e 65 to 70% heat energy lost to environment.

Transmission and Distribution

a. Step-up station – 99.5%

b. EHV transmission – 99.0%

c. HV transmission – 97.5%

d. Sub transmission – 96.0%

e. Distribution station – 99.5%

f. Primary distribution – 95.0%

Overall efficiency at end users premises – 99.5x99.0x97.5x96.0x99.5x95.0= 83.0%

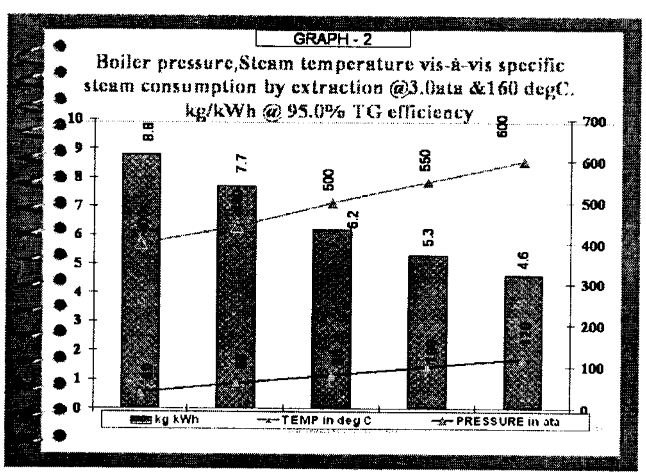
i.e 17 % energy is lost in Transmission & Distribution system.

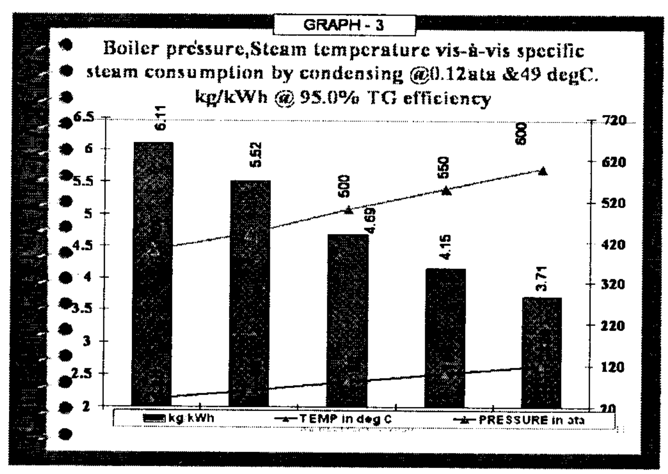
END USER STATION :

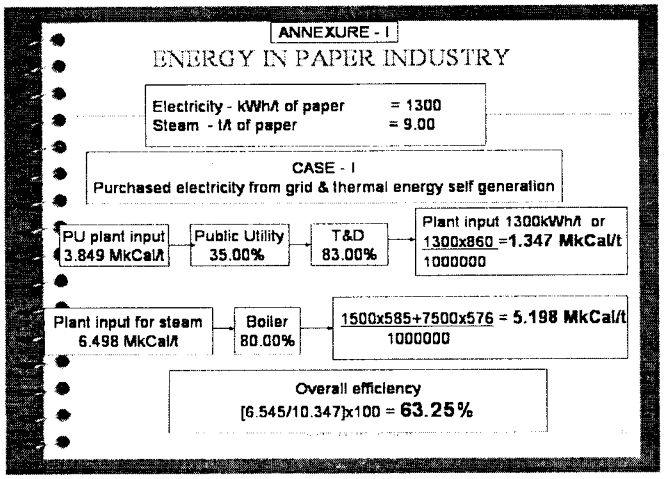
a. End user distribution – 95.0%

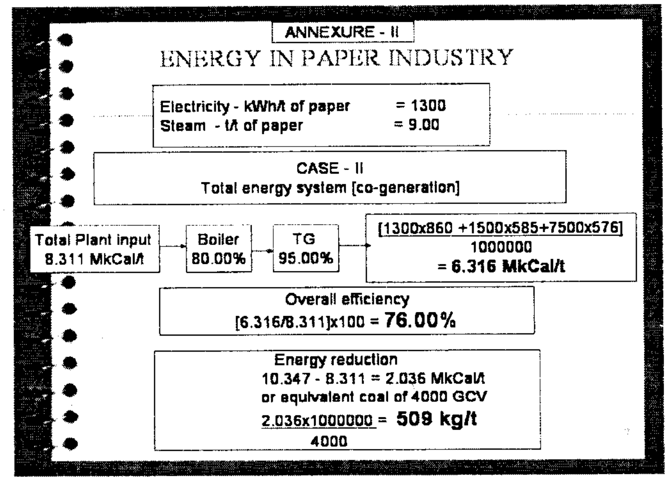
b. Motor efficiency – 90.0%

c. Driven equipment efficiency – 70.0%









Overall efficiency in the end user premises – 95.0x90.0x70.0 = 59.85%.

i.e 40% is lost in an industrial users premises.

OVERALL ENERGY SYSTEM EFFICIENCY AS A WHOLE FROM FUEL TO END USE AT CUSTOMER PREMISES = 35.0X83.0X59.85

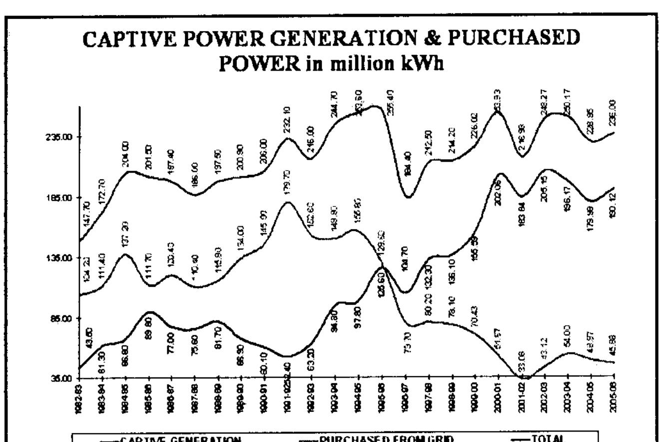
= 17.39 %

That is to use ONE unit output at the consumer premises nearly SIX unit equivalent energy input in the form of fuel to be used in generating station. To get 860 kCal i.e.one kW energy, we have to put in 4945 kCal into generating station from the energy sources. Figure. 1.

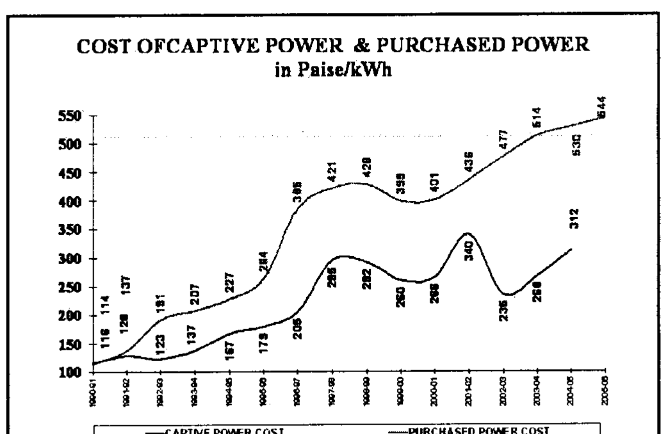
Looking at the huge energy loss in the centralized power generation, transmission, distribution and utilization from the public utilities. Alternative power generation at the consumer premises can be looked at where considerable process heat requirement is there.

Taking the example of pulp and paper industry, where 9.0 tons of steam and 1300 kWh electricity is being proposed as the norm to produce one ton of paper. Potential energy savings in terms of coal of 4000 GCV has been worked out in the annexure-I & II. This shows the opportunity for pulp and paper industry to contribute its might in saving the environment. Today in India around 5.5 to 6.0 million tons of paper is produced. Potential for fuel saving by adopting CHP system.

When Indian Pulp & Paper industry was using only low and medium pressure boilers for its process steam requirements in the past. THE MYSORE PAPER MILLS LIMITED took a lead to install high-pressure boilers of 64 ata and 450°C steam parameters with steam turbines to generate heat and power together way back in 1978-80. Further it has moved progressively by installing 2500TCD integrated sugar mill during 1984 to augment co-generation power and to make use of renewable energy for papermaking. Thus, MPM stood in the forefront in co-generation, renewable energy utilization and resource conservation. MPM has started its massive afforestation programme simultaneously to preserve the ecology. It can be seen from the graph – P1 where in



GRAPH-P1



GRAPH-P2

continuous improvement in captive power generation, reduction in grid power consumption and associated cost benefit over the purchased power from the graph – P2

CONDENSATE MANAGEMENT

Condensate is a precious source of residual thermal energy in the system.

Heat content of condensate varies from process to process depending on pressure of steam at which it is transferring heat to the process.

Condensate is De-mineralized water, which costs more to process raw water especially in case of high-pressure boilers.

Improved condensate recovery saves energy, money and environment by reducing the consumption of chemicals like Hydrochloric acid and Caustic Lye used for regeneration of resins in the De-mineralization Plant.

Rise in boiler feed water temperature by every 6.0°C increases boiler efficiency by 1.0%

Benefits can be seen from data – C1.

THERMAL INSULATION

Thermal insulation is another very vital area where energy loss to the environment is reduced in turn reducing the fuel consumption for raising steam.

CONCLUSION

It is prudent to note that without energy there is no life. Energy is precious. It is to be converted from one form to another useful form at the highest efficiency possible. Energy is to be used more efficiently to conserve the resources. Power generation in process industry is one of the more efficient way of utilising the energy. It should be made mandatory to adopt Combined Heat and Power (CHP) system in all the process industries,i.e co-generation.

Government and Financial institutions should come forward liberally to finance co-generation systems.

It should be made mandatory to buy surplus power from all the process industries at remunerative price by the Public Utilities.

Central Electricity Regulatory authorities should clarify to State Regulatory authorities and Public Utilities that power generation in sugar industry is not the only co-generation. Power generation in all the process industries is to be treated on par irrespective of the type of the fuel used in view of improved cycle efficiency and resource conservation.

Process industries are to be encouraged to develop energy systems with locally available renewable/non-renewable energy sources to eliminate huge T&D loses and fuel hauling expenses.

Boiler pressure and steam temperatures adopted for co-generation should be made as high as possible to improve the cycle efficiency.

REFERENCES

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BEE course material for Energy Auditors exam 2004. Steam tables.