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ENERGY SAVING IN INDUSTRY

DP/PAK/83/009

PAKISTAN

Technical report: Consultancy and training in energy conservation*

Prepared for the Government of Pakistan
by the United Nations Industrial Development Organization,
acting as executing agency for the United Nations Development Programme

Based on the work of John Denbigh,
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United Nations Industrial Development Organization
Vienna

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Abstract

ENERGY SAVING IN INDUSTRY - TRAINING OF LOCAL STAFF
DP/PAK/83/009/11-51

Objective: The main objective of the activity was to train local staff in the use of energy measuring instruments in the procedures for industrial energy audit surveys and collection of data required for effective energy conservation. Methods of analysing data collected to obtain monitoring and targetting figures for specific industries were covered. Any use of renewable resources was considered in the specific industries covered and economics of various methods of energy management and conservation were described.

Duration of Activity: One and a half months.

Main Conclusions and Recommendations:

The main conclusion was that the almost complete lack of instrumentation in the form of steam meters, water meters, fuel meters and temperature indications on the plants visited precluded any detailed energy audit. Instruments provided for use of local staff under a previous part of this project were of a sophisticated nature and due to faults developed in their operation some were either not indicating or giving suspect readings. Local staff were therefore unable to carry out complete energy audits and were severely restricted in achieving any detailed results.

1. It is recommended that simpler and more robust instruments are considered so that not only can instruments be serviced locally but more audit teams could be equiped in the future so enabling an increase in energy audits.

2. It is recommended that all Energy Statistics are given in SI-units.

3. It is recommended that an Energy Manager be appointed at each factory.

Explanatory Notes:

$ 1	=	Rs.17.23
Rs. 1	=	$ 0.058
D.G.N.R.E.R.	=	Directorate General of New and Renewable Energy Resources.
1 W	=	1 J/s
1 kWh.	=	0.0036 GJ
1 GJ	=	277.78 kWh.
H.C.V.	=	Higher Calorific Value.
L.C.V.	-	Lower Calorific Value.
l	-	Litre.

Specification of Furnace Oil.

Specific Gravity	-	0.96 Approx.
H.C.V.	-	42,938.5 kJ/kg.
		41,131 kJ/l
k	-	10^3
M	-	10^6
G	-	10^9
P.F.	-	Power Factor.
Btu	-	British thermal unit (1Btu = 1,055kJ
psi	-	pounds per square inch (1psi = 68,95 mbar)
lb/hr	-	pounds per hour (1lb/hr = 0,454 kg/h)
ft	-	feet (1ft = 0,3048m

Introduction:

The project activity was defined as :-

1. To train local staff in;

   a) Procedures for industrial energy audit surveys and collection of data required for effective energy conservation.

   b) Analyses of data collected including the analysis of total energy demand, peak energy demand, waste heat recovery at the plant level improving the performance of steam boilers and leading to a reduced consumption of fuel oil, gas, coal etc. without affecting industrial output.

   c) Fuel substitution including the utilisation of renewable sources of energy in the industrial sector.

   d) Economics of various methods of energy amanagement and conservation.

   e) Handling equipment supplied under the project.

The activity was part of the implementation of an integrated programme of energy savings.

The activity commenced in Pakistan on 26 March 87 and lasted until 3 May 1987.

All the original objectives of the activity could not be achieved due to the almost complete lack of instrumentation in the form of steam meters, water meters, fuel meters and temperature indicators on the specific plants visited. Similarly important instruments provided under a previous part of this project had developed faults and could not be maintained locally so that local staff were severely restricted in the amount of data that could be collected to enable them to carry out complete energy audits and provide detailed analysis and recommendations.

Nevertheless with the data available competent work was carried out and audits and recommendations were made for each factory visited.

Recommendations:

1. The instruments provided under the previous part of this contract are of a sophisticated nature. Spares including a special flat power pack cannot be obtained locally so that even if the instruments themselves can be made functional in local workshops they will be inoperable until spares can be delivered. Furthermore normal maintenance involves sending the instruments away and if a serious fault develops local staff are completely unable to carry out audits. It is, therefore, recommended that simpler and more robust instruments are provided so that not only instruments can be serviced locally but more audit teams could be equipped in the future so enabling an increase in energy audits.

Instruments should include :-

a) Boiler Combustion Efficiency Testing:

"Fyrite", Baccarach or Brigon CO_2 or O_2 flue gas analyser complete with thermometer and smoke density measuring unit.

b) Humidity Measurement:

Wet and dry bulb swing thermometer.

c) Draught Gauge an Air Velocity Measurement:

Water manometer complete.

d) Temperature Measurement:

Various short tail and long tail vertical and horizontal dial thermometers for liquids and flue gases. Ranges;

0	-	100°C
0	-	200°C
100°	-	350°C

These instruments should be procurable locally either being of indigenous manufacture or obtainable from local agents.

2. During the work on analysing fuel data and costing recommendations great difficulty was encountered because of the non coherence of data units and in some cases ambiguities (e.g. the previous part of this project used 'M' to be 10^6, whilst the Pakistan Energy Year Book 1985 used "M" to mean 10^3) (gas prices were given as Rs. per MCFT). It is strongly recommended that the government convert all statistics to the SI system.

3. It is recommended that the Government consider a campaign to encourage industry to appoint Energy Managers at each factory. These Energy Managers should be of managerial status with sufficient authority to enable their recommendations to be implemented. They should be responsible for the accumulation of all data on energy including quantities purchased, costs and analysis of use on the factory. The setting up of targets or norms for energy used per unit of product should be a prime consideration so that monitoring and targetting can be undertaken. Day to day good housekeeping should be an ongoing concern.

Activities and Output General :

Three factories were selected for the purpose of the activity. They were;

a) Pakistan Tobaco Industries - Mandra.
b) Alliance Textile Mills Ltd. - Jhelum.
c) Heavy Foundry and Forge - Taxila.

The local staff interviewed the various officers at the factories and obtained data relative to the auditing of energy using activities with instruments provided by the first part of this project., The possibility of fuel substitution particularly with regard to the utilisation of renewable sources of energy was examined.

Readings were taken by counterpart staff of a large number of parameters relative to energy use. The heuristic method of training was used that is counterpart staff took data and readings themselves in order to gain necessary experience of the use of instruments and the importance and relevance of different types of data.

As has been stated before the activity was severely restricted by non availability of some instruments but much valuable experience was gained particularly with regard to the use of that data that was actually processed.

The use of data towards energy conservation was covered by using a series of examples. These have been appended as Annexes and are designed to be models for the application of present and future energy audits so that energy saving actions can be quantified.

Instruments supplied first part of this contract included :-

a) Infrared Pyrometer.
b) Exergen Heat Radiation Scanner.

The Infrared Pyrometer originally showed no reading but after some attention did register. However the readings obtained were suspect and could not be relied upon. This meant that readings at the Heavy Foundry and Forge at Taxila were limited.

The Exergen Heat Radiation Scanner is processed by a special flat Polapulse Battery pack. Batteries supplied under the first part of the contract (12) were all discharged and no readings could be taken as these batteries are not available locally. This meant that any radiation loss could only be estimated and therefore analyses such as overall boiler efficiency lacked actual measurements. Losses from furnaces were also impossible to measure. Nevertheless the application of these instruments were appreciated by counterpart staff. As well as the principle used as examples in the Annexes calculations were also carried out on the basis of coefficients of performance of refrigeration plant and on the use of Psychrometeric Charts to determine excess moisture content (provided by steam) in air which is required at a specified Relative Humidity. This was done in the case of the Pakistan Tobacco Industry and large savings were identified.

Detailed Energy Audits and recommendations are given in Annexures XI, XII and XIII

Utilization of the Results of the Activity.

It is expected that the findings and recommendations in the Energy Audits carried out will be communicated to the factories which were subject of the activity. Dependent upon how much of the recommendations are carried out by the factories concerned considerable economic energy savings can be made.

Furthermore with the experience gained and examples of energy saving exercises appended to this report further energy audits can be carried out and recommendations made leading to energy savings on a national scale.

It should be noted that in this part of the project the energy surveys and audits produced from data obtained were the work of the counterparts themselves as opposed to those carried out in the first part of the project when counterparts were not involved in the analysis of data or making recommendations.

This part of the project was therefore invaluable to the counterparts.

Conclusions.

It is concluded that without the personal involvement of counterparts in all parts of energy surveys and audits including calculations and full understanding of the detailed basis of any recommendations made further work by counterparts or their staff or successors will be severely hampered if not impossible.

ANNEXURE-I

COUNTERPART STAFF

1.	Mr. Mohammad Iqbal, Director (Incharge).	DGNRER
2.	Mr. Shahab Alam, Deputy Director (Technical)	DGNRER
3.	Mr. Sher Mohammad Khan, Assistant Director (Technical)	DGNRER
4.	Mr. Mohammad Bashir, Sub-Engineer.	DGNRER
5.	Mr. Muzaffar Hussain Shah, Assistant.	DGNRER
6.	Syed Azhar Abbas, Stenotypist.	DGNRER
7.	Syed Arshed Hussain, Stenotypist.	DGNRER
8.	Mr. Dildar Hussain Shah, Driver.	DGNRER
9.	Mr. Ghulam Nabi, Naib Qasid.	DGNRER
10.	Shahid Pervaiz, Draftsman.	DGNRER

ANNEXURE-II

Heat in Steam

The total heat in saturated steam consists of two main parts - the sensible heat and the latent heat.

a) Sensible Heat: The sensible heat is the heat which actually causes temperature increase (that is it can be sensed (sensible). This sensible heat is required to raise the temperature of water (a liquid) to boiling point at which temperature any additional heat will not be followed by a temperature increase but will contribute to changing the state of water (a liquid) into steam (a gas).

b) Latent Heat: The heat required to change the water to steam is called the latent heat. Both the sensible heat and latent heat required to change a given quantity of water into steam depend upon the pressure on the liquid.

c) Total Heat of Steam: The total heat of steam consists of both the sensible heat and the latent heat.

Example 1:-

Sensible Heat. The sensible heat in water in kJ/kg. is found by multiplying the temperature of the water in degrees centigrade by 4.187 approximately.

Sensible heat in water at 25°C
= 4.187 x 25 =104.68 kJ/kg.

Sensible heat in water at 60°C
= 4.187 x 60 = 251.22 kJ/kg.

Note: The 'sensible heat' is a term which is now superceded by the term 'specific enthalpy of water' but 'sensible heat' is used throughout this report.

<u>Latent Heat:</u> The latent heat is obtained from steam tables.

Latent heat in steam at 7 bar.
= 2047.7 kJ/kg.

<u>Note:</u> The "Latent heat" is/term which is now superceded by the term "specific enthalpy of evaporation" but "latent heat" is used through this report.

<u>Total Heat:</u>

The total heat (Specific enthalpy of steam) is obtained from steam tables.

total heat in steam at 7 bar.

= 2769 kJ/kg.

Combustion Efficiency:

The efficiency of a boiler will depend upon a number of factors - for example, radiation losses, amount of flow-down etc but the most important parameter is normally the efficiency of combustion.

Any fuel requires Oxygen to burn some fuels such as rocket fuels and explosives may contain their own intrinsic oxygen but the vast majority require the supply of oxygen from an external source, This again is in the normal case supplied by air which has same 20.9% by volume of oxygen in its make up. The remainder is mainly the inert gas nitrogen which does not burn. The ideal ratio between the fuel and air to produce complete combustion and no excess air is turned the stoichiometric ratio. In practice this minimum amount of air is rarely achieved and certainly never in the case of the medium to small industrial boilers. It is normally necessary to provide a considerable amount of excess air to provide complete combustion due to the inadequacy of the burner system to provide complete mixing with combustion air. Too little combustion air will mean that fuel passes through the boiler and remains unburnt so being wasted and giving a low efficiency. Too much combustion air on the other hand means that the heat from the fuel is not only going to provide heat to the boiler and to the requisite volume of flue gases, but is also going to heat up large volumes of excess air which pass out of the boiler, without doing any useful work. The ratio of oxygen to fuel cannot practically be measured at the intake of boilers and in any event would not show how the fuel and oxygen were being used. Measurements are therefore taken as near to the outlet of the boiler as possible and will show the amount of excess air and coupled with temperature readings can be used to calculate combustion efficiency. These calculations are now-a-days shortened by the use of tables, charts or specially designed instruments containing circuits which can take into account ambient temperature, flue gas temperature and oxygen percentage by volume and show a direct reading of efficiency.

It should be mentioned at this stage that there are two different combustion efficiencies which are used. These depend on whether the net (on lower calorific value LCV) or gross (on higher calorific value HCV) of the fuel are used. The HCV is used in the UK and the USA but most European countries use the LCV for calculating efficiencies. The difference between LCV and HCV is that the LCV disregards the amount of energy required to convert the hydrogen in the fuel into steam. With fuels having little or no hydrogen in their make up the LCV and HCV and the respective combustion efficiencies will not differ a great deal but were the hydrogen content is appreciable as in the case of oil fuels and more-over natural gas the efficiencies will vary considerably for example with oil fuels this could be say 6 percentage points e.g. combustion efficiency HCV - 76% - combustion efficiency LCV - 82%. It is therefore exceedingly important to know whether or not efficiencies are based upon HCV or LCV. This point was not highlighted in the original report and it is assumed that HCVs have been used. Moreover boiler plant literature may not always state upon which basis (HCV or LCV) stated efficiencies are obtained. Continental European boilers although of the same or less actual efficiency as UK or USA boilers will claim higher efficiencies than the UK or USA boilers. Similarly to take these figures and expect to achieve them with table, charts or instruments based on HCV will obviously be impossible. Following on the previous report and instrument provided HCV is used in this part of the project.

It would be noted that a smoke test should be taken in conjunction with the flue gas oxygen (or Carbon-dioxide) analysis. Smoke is obviously a result of incomplete combustion of fuel and the burner should be adjusted until this as been brought to an acceptable level (No.1 on the smoke scale).

Example Using Charts: An oilfired fire tubed boiler has a flue gas temperature of 232°C and the flue gas analyser shows an oxygen of 7.8. With an ambient temperature of 20°C the flue gas loss is shown to be 18% giving a combustion efficiency of 82%.

Overall Boiler Efficiency.

As has been stated the overall boiler efficiency depends upon other parameters than the combustion efficiency. The amount of blowdown required will obviously detract from the amount of steam being produced as will the amount of radiation loss. Although it may be possible to measure the amount of blowdown this is rarely done and it is normally carried out on an ad-hoc basis of a given period of time per shift or day etc. It is obvious that reducing blowdown will increase steam output. It is also possible to try to recover the heat from blowdown by various means for example in the case of continuous blowdown a heat exchanger for pre-heating the feed water could be employed. Radiation losses are dependent upon the degree of insulation of the boilers. Old boiler plant in particular may be badly insulated originally or the insulation may have become defective. In these cases improved insulation may be justified. Radiation losses may be measured directly by means of the Exergen Heat Radiation Scanner provided under the first part of this project. Unfortunately during the current period this instrument was not operating due to the run down of the special flat power pack which is not available locally. The alternative to this is to assume that the boiler shall (in the case of fire tube boilers) is regarded as a large diameter pipe containing hot fluids at the temperature of steam generation - heat losses from charts provided under this part of the contract can be used to ascertain losses when used with various thicknesses of insulation. The input of heat to be boiler consists of three main parts :-

a) Heat contained in the fuel.

b) Heat contained in the combustion air.

c) Heat contained in the feed water.

a) The heat in the fuel is given by the value. As stated in this part of the project the HCV is used. Therefore with a given volume of fuel the heat contained can be found, if in the case of liquid fuel the specific gravity is known. The boilers seen on this part of the project were all fired with No.6 fuel oil which has a given calorific value (HCV) of 42938.5 kJ/kg. or 41,131 kJ/l at .96 approx. specific gravity.

b) The heat contained in the combustion air is almost always given by the ambient temperature of the boiler house. That is the air which is being drawn in to the boiler. In some special cases, however, the combustion air is preheated by some means. The commonest methods is to draw the air over the outer shell of the boiler between it and some outside casing. This was the case with the water tube boilers at the Heavy Foundry and Forge and this would make the temperature of the combustion air difficult if not impossible to establish with any accuracy.

c) Heat contained in the feed water can easily be ascertained by taking the temperature in C^o and multiplying by 4.187 to give a value of kJ/kg.

e.g. Feed water temperature is 55°C therefore heat contained in each kg. = 55 x 4.187 = 230.3 kJ/kg.

This heat is of course not provided by the fuel and should therefore be deducted from the total heat of the steam when establishing the part played by the fuel.

With the oil fired boiler previously quoted having a combustion efficiency of 82 percent the overall efficiency may be only 75 percent as follows:-

Flue gas loss	18 percent
Radiation etc. loss	4 "
Blowdown loss	3 "
Total loss	25 "

Overall Boiler Efficiency = 100 - 25 = 75%

The direct method would be to meter the quanitty of fuel being actually used to provide an actual quantity of steam. This is why it is important that individual boilers are provided with fuel meters and steam meters (or failing that water meters).

<u>Example</u>:

A boiler uses 500 litres of furnace oil and the quantity of water supplied to the boiler is 6000 l. The boiler in operating at 8 bar and the feed water temperature is $50^{o}C$. Assuming that during the test period there is no blowdown what is the efficiency of the boiler (HCV)?.

From previous work we know hat furnace oil has a HCV of 41,131 kJ/l. The heat supplied is therefore (41,131 x 500) kJ. As there is no blowdown all the water will be produced as steam. The fuel will have provided all but the sensible heat in the feed water.

Heat from fuel in each 1 kg of steam
= 2774 - (4.187 x 50)
= 2564.65 kJ/kg.

Assuming 1l of water weighs 1 kg. (not quite accurate as temperature is 50°C) we have produced (6000 x 2564.65) kJ from (41,131 x 500) kJ of furnace oil.

The efficiency is therefore

$$\frac{16000 \times 2564.65}{41131 \times 5000} \times 100 = 74.8\%$$

If blowdown normally accounts for a loss of 3% the overall efficiency will be 74.8 - 3 = 71.8%.

ANNEXURE-V

Cost of Steam.

The cost of steam is a composite one consisting of all boilers house overheads such as labour, electricity, water treatment, general factory administrative costs, maintenance costs, water costs and of course fuel costs. Without detailed boiler house accounts assumptions have to be made regarding the contribution of each cost to the total cost. In UK a normal figure would be that 85% of the total is due to the fuel cost but with lower labour costs in Pakistan it may be reasonable to assume 90% in fuel cost. Therefore very roughly we can say that almost all the saving in steam costs is reflected by the fuel cost to produce it, as the other charges are mainly fixed and will not alter at the margin.

Example:

What is the cost of 1000 kg. of steam at 8 bar. (with feed water at $50^{o}C$) produced from furnace oil at Rs.1.62 per litre when the boiler is operating at 70 percent efficiency.

1000 kg of steam contain

$$1000 \times \quad 2774 - (4.187 \times 50) \quad kJ$$
$$= 2564.64 \times 1000 \text{ kJ.}$$

1 l of oil at 70 percent efficiency will produce (41,131 x 0.7) kJ.

Cost of 1000 kg of steam

$$= \frac{2,564.64 \times 1000 \times 1.62}{41,131 \times 0.7} = \text{Rs.}144.30$$

Heat in Condensate.

Any heat in condensate returned to the boiler will obviously contribute to the heat total. Increasing the temperature and/or quantity of condensate return will reduce fuel costs.

Example :

1500 kg of condensate per hour at $80^{o}C$ is returned to the boiler operating at 75% efficiency to replace 1500 kg of mains water at $20^{o}C$. What is the saving in fuel costs if the boiler is working 7000 hours per year ?

Condensate recovered 1500 kg/h

x Hours per year. 7000

10,500,000 kg/y

Extra Heat in condensate above feed water = (80-20)x 4.187 kJ/kg.

= 251.22 kJ/kg.

Heat recovered = $251.22 \times 10{,}500{,}000 \times 10^{-6}$ GJ

= 2,637.81 GJ.

Boiler efficiency = 75 percent therefore required heat from fuel $= \frac{2637.81}{0.75} = 3{,}517$ GJ.

1 litre of oil contain 41,131 kJ

$\frac{3{,}517 \times 10^{6}}{41{,}131}$ l are required = 85,507.2 l

which at Rs.1.62 per litre

= Rs.138,521.7 per year.

ANNEXURE-VII

Reduction in Steam Demand - Solar Energy.

It is obvious that reducing steam demand will reduce fuel costs. An example from a process plant demonstrates the methods of calculating savings and also shows the possible use of solar energy.

Example:

Washing water is required at 60°C at the rate of 1000 l/h . Normally the water is provided by mains water at 20°C heated by direct steam injection. If by the use of solar panels the supply water temperature is increased to 40°C what is the percentage saving in steam? What is the cost saving per year if the process is operating 7000 hours per year and the boiler is operating 8 bar at 55% efficiency and steam main losses are 15%.

Heat required to raise 1 l (1kg) of water through (60 - 20)°C = 40 x 4.187 kJ = 167.5 kJ therefore heat required for 1000 l

= 167,500 kJ.

Heat required in steam = 167,500 kJ

Heat required at boiler outlet due to mains losses. $= \frac{167,500}{.85}$

= 197.059 kJ.

Heat content in steam at 8 bar. = 2,774 kJ/kg.

$\therefore \frac{197,059}{2,774} = 71$ kg of steam are required.

With water supplied at 40°C heat required = (60 - 40)°C x 4.187 = 83.75 kJ/l and only 35.5 kg of steam are required therefore saving

$= \frac{35.5}{71} \times 100 = 50\%.$

If the process operates for 7000 hours per year 1,97,059 x 0.50 x 7000 kJ are saved at boiler outlet per year.

$$=197,059 \times 0.50 \times 7000 \times 10^{-6} \quad GJ$$

$$= 690 \text{ GJ.}$$

As boiler efficiency is 55% the fuel oil is required to provide $\frac{690}{0.55}$ GJ.

$$= 1,254.5 \text{ GJ}$$

1 l. fuel oil has a HCV of 41,131 kJ

$$\therefore \text{ litres required} = \frac{1,254 \times 10^6}{41,131}$$

$$= 30,500 \text{ l}$$

and Rs. saved at 1.62 Rs/l

= Rs.49,410 say Rs.50,000/-

If a payback of 6 years is acceptable for the use of solar energy the expenditure of 6 x 50,000 = Rs.300,000 is justified.

Losses from Hot Pipes or Surfaces.

All hot surfaces radiate heat and also lose heat by convection. These losses can be calculated from first principles but this is a very laborious process and tables of charts are normally used. Charts showing losses from insulated and bare pipes have been left for use by personnel. Although losses have been given for pipes only, larger sufaces can reasonably regarded as correspanding to pipes of 500 mm diameter. It will be noticed that even the thinnest insulation reduced heat losses by some 90% so that even if the economic thickness of insulation is not applied it essential that some insulation is applied. The use of the charts is adequately described in their accompanying notes and will not be repeated here.

Example:

A steam valve on a 100 mm pipe is uninsulated. The pressure of steam is 10 bar and the boiler efficiency is 55 per cent and the operating period 7000 hours per year Assuming a two year payback as acceptable what amount of money is justified in providing a valve insulation box ?

The temperature of steam at 10 bar is 184.13°C. Assuming that the average temperature of the outside of the valve body is 150°C the heat loss will be equivalent to that from 1 m of 100 mm of pipe.

From charts = 850 W

Therefore loss per year = $850 \times 3600 \times 7000 \times 10^{-6}$ GJ

= = 21.420 GJ

And for 2 years = 42.84 GJ.

42.84 GJ are lost but with boiler efficiency of 55%

$\frac{42.84}{0.55}$ GJ must be provided by fuel

= 77.89 0 GJ.

As the HCV of fuel oil is 41.131 kJ/l

$= \frac{77.89 \times 10^6}{41,131}$ = 1,893 l.

and at Rs.1.62 per litre = 1893 x 1.62

= Rs.3,067

Therefore Rs.3067 is justified if a two year payback is required.

(For a 1 year pay back half this amount i.e. Rs.1535 is justified).

Calculation of Power Factor(P.F)

The importance of power factor to the supply industry is that all the supply system, power generators distribution calles transformers, switch gear etc. have to be provided to carry current some of which as for as the user is concerned is wattless, that is it does no work and does not register on a kwh meter. Furthermore I^2R losses in the distribution cables will be greater than if the user uses the current supplied efficiently. The user is encouraged to use a P.F over 0.85 as charges are applied if the actual P.F is less. It is not proposed to examine the detailed theory of P.F but it will be useful to be able to calculate P.F from standard electricity bills.

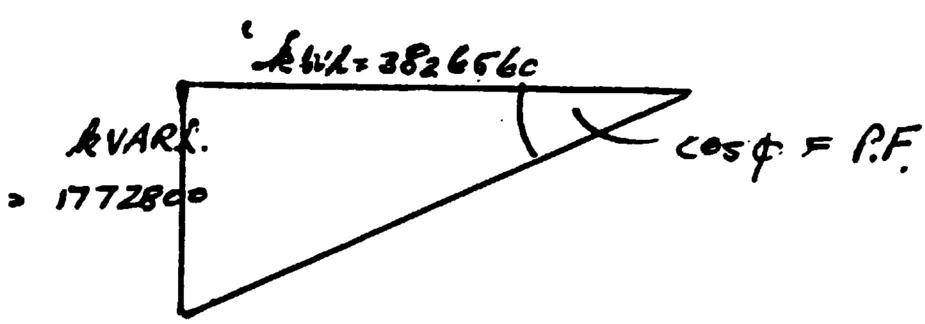
Example

The electricity bill shows (inter alia) the following readings.

kWH - 3826560
kVARH - 1772800

What is the power Factor?

From the vector diagram cos ϕ = PF



By calculation the by hypotenuse of the vector diagram is 4217271.7

and $\cos\phi = \frac{3826560}{4217271.7} = 0.907$

P.F = 0.9

ANNEXURE-X

Economic Criteria.

There are numerous methods of economic appraisal. The particular method used will usually depend on that accepted by finance departments as most suitable to their own situations. For example small private industry may look for relatively simple methods whilst large government departments will use more sophisticated techniques. It is proposed to outline three variations which can be used. They are; (a) simple payback (b) Lowest cost in Use (c) Techniques using Discounted Cash Flow, Test Discount Rates and Net Present Value.

(a) Simple Payback.

Simple payback has been used as a criterion in the first part of this project. It is an extremely simple method and now a days is considered outdated.

Example:

With gas at Rs.3.33 per m^3 and a boiler efficiency of 75% based on HCV a 25 mm pipe operating at as shown in the table below:

Thickness of Insulation mm	Heat loss W/m	Cost of Heat Loss Rs/annum	Installed Cost of insulation Rs./meter	Payback period Years.
Bare	78.00	73.8	-	-
9	21.57	20.4	51	0.96
13	17.80	16.8	58.5	1.03
19	14.50	13.8	.87	1.45
25	12.50	11.7	112.5	1.81

b) Lowest Cost in Use.

The lowest cost in use is a technique which establishes the benefits of taking different conservation actions against costs and produces a point at which additional conservation action actually starts to increase total costs. The period of review is not limited and is extended only so far as an increase in total costs are indicated. This principle can be illustrated graphical in Fig. 1 It should be noted that although smooth curves are indicated in real life there may be steps in the lines as for example insulation thickness will not increase by infinite steps but more by predetermined thicknesses dependent upon manufacturers products.

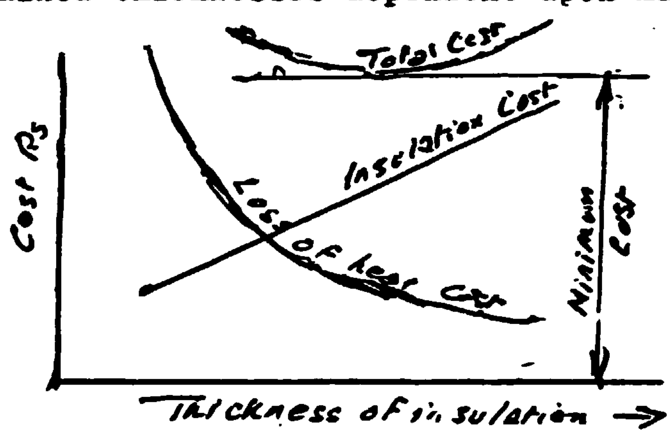


Fig 1.

Example.

A 50 mm bore pipe operating at 100°C os to be insulated. The boiler efficiency is 75% using HCV and the fuel cost Rs.5.1/litre. The pipe will be in use for 5,400 hours per year and the evaluation period is 5 years.

Thickness of insulation	Heat loss	Cost factor	Cost of heat loss over evaluation period	Installed cost of insulation	Total Cost
mm	W/m	Rs./W	Rs/m	Rs/m	Rs./m
Nil	245	15.9	3885	-	3885
50	20	15.9	318	153	471
63	17.6	15.9	279.9	186	465.9*
75	16	15.9	254.4	225	479.4

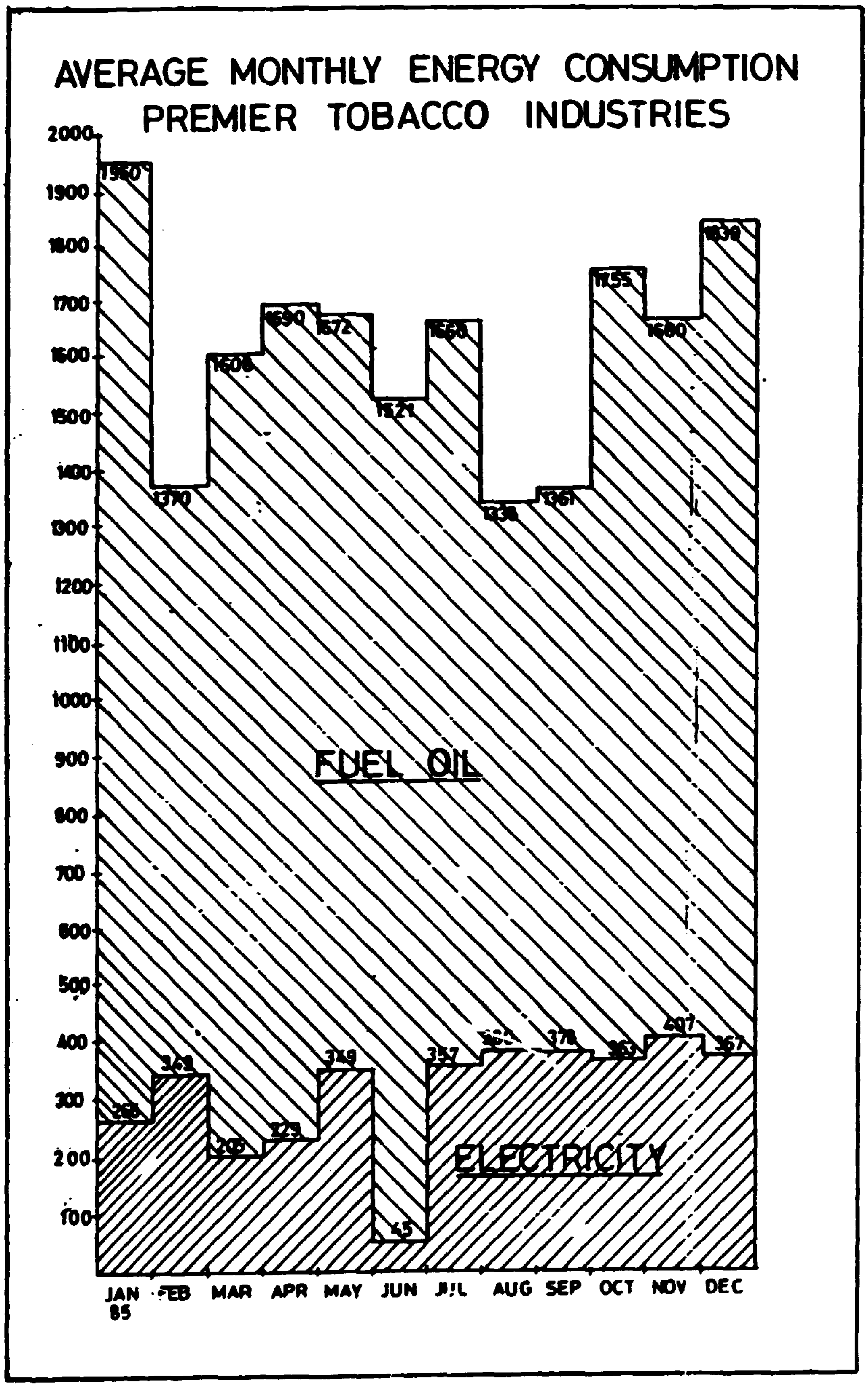
* Lowest cost in use and economic Thickness.

Discounted Cash Flow.

Discounted Cash Flow is a technique which takes into account the interest rates which are considered to be relative to the project. It will be evident that if a sum of money is invested in a project for the purpose of energy conservation bringing in a saving in energy costs the same amount of money could be invested in some financial areas which would also produce an income. Similarly if money is borrowed to finance an energy conservation project the interest payable on this loan will have to be set against any energy cost savings. It must be emphasised that this technique does not take into account inflation across the board. If it is assumed that certain costs, for example energy costs, will increase at a greater rate then other costs a different test discount rate should be used for the fuel costs. For example if energy costs are expected to increase 2% per annum in real terms (real terms means relative to a total basket of other costs) then the relative Test Discount Rate (TDR) used for energy costs or savings would be 2% less than the test discount rate used for other costs. Using this technique it is normal to set a period for the time reviews e.g. life of the project.

By bringing all costs present and future (discounted in line with whatever discount rate is decided upon) a Net Present Value (NPV) can be obtained which enables the choice of projects to be made. Those with the lowest NPV will be more attractive.

To enable this technique to be used sets of tables are available to give appropriate factors for different interest rates and evaluation periods.


AVERAGE MONTHLY ENERGY CONSUMPTION
PREMIER TOBACCO INDUSTRIES
2000
1900
1800
1700
1600
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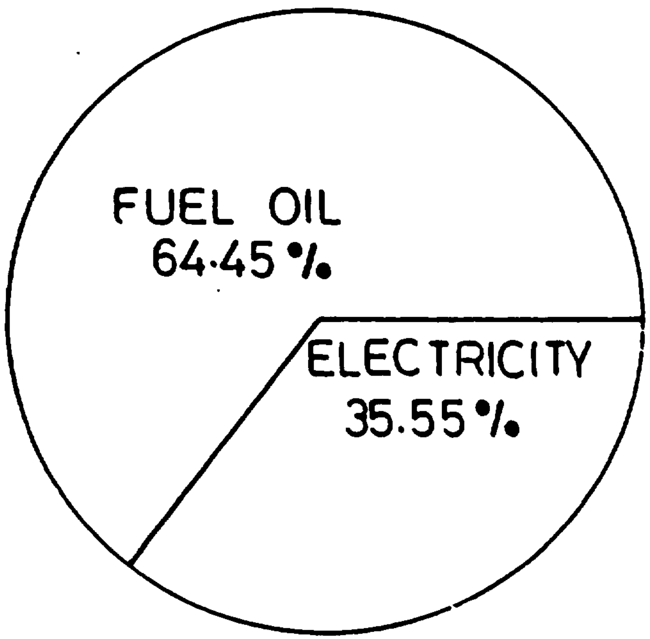
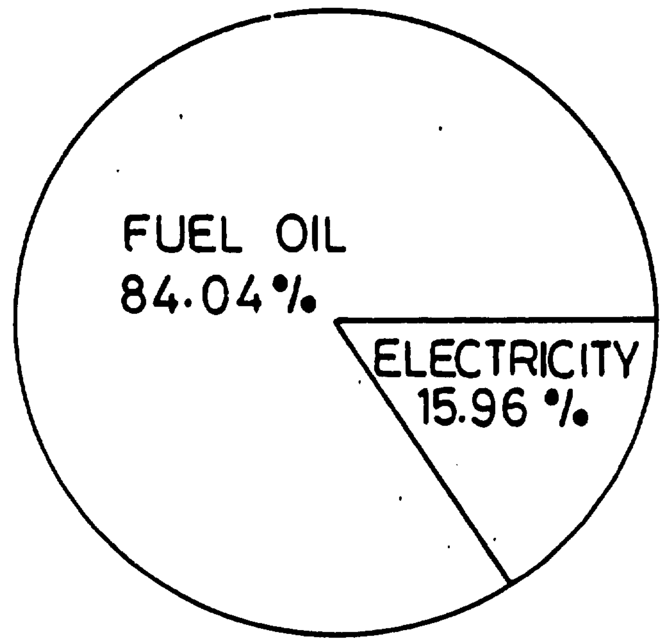
1100
1000
900
800
700
600
500
400
300
200
100
1370
1606
1690
1672
1660
1680
1755
1839
FUEL OIL
349
357
378
407
367
45
ELECTRICITY
JAN 85
MAR
APR
MAY
JUN
AUG
SEP
OCT
NOV
DEC

ENERGY DISTRIBUTION

BY COST



BY TYPE



PREMIER TOBACCO INDUSTRY
BY COST AND BY TYPE OF ENERGY CONSUMED

BOILER

PREMIER TOBACCO INDUSTRIES

Assuming 90% of the fuel oil is consumed in the boiler

DETAILED ENERGY USE & COSTS

Month	Total Oil Consumed Litre	90% of Oil consumed liter	Energy GJ	Steam Production (100%) Kg	Actual Steam Produced (55%) Kg	Steam Production at 78% efficiency Kg	Fuel oil Saving	Saving in Rs.
January 85	47275	42547.5	1750.02	369272.79	203100.03	288032.77	12546.05	20324.601
February	33200	29880	1228.99	259330.65	142631.85	202277.90	8810.76	14273.43
March	38990	35091	1443.32	304557.29	167506.50	237554.68	10347.34	16762.69
April	40960	36864	1516.25	319945.29	175969.90	249557.32	10870.15	17609.64
May	40550	36495	1501.07	316742.71	174208.49	247059.31	10761.34	17433.77
June	36875	33187.5	1365.03	288036.68	158420.17	224668.61	9736.05	15853.40
July	40225	36202.5	148.17	314204.08	172812.244	245079.18	10675.09	17293.64
August	32450	29205	1201.23	253472.28	139409.754	197708.378	8611.73	13951.0026
September	33000	29700	1221.59	257768.42	141772.631	201059.36	8757.69	14187.45
October	42556	38300.4	1575.33	332411.91	182826.55	259281.28	11293.70	18295.794
November	40250	36225	1489.97	314399.36	172919.64	245231.50	10681.73	17304.402
December	44575	40117.5	1650.07	348182.65	191500.45	271582.467	11829.51	19163.80
		423815.4	17431.95	3678324.18	2023078.29	2869092.86	124971.20	202453.344

Pay back period $= \frac{660000}{202453.44} = 3.26$ **years.**

PREMIER TOBACCO INDUSTRIES MANDRA

FUEL OIL CONSUMPTION

Month	Liters	M.T	G.J	Cost	Rs./GJ
January 85	47275	45.38	1949.97	83931	43.04
February	33200	31.87	1369.45	59100	43.15
March	38990	37.43	1608.37	67640	42.05
April	40960	39.32	1689.58	68733	40.68
May	40550	38.92	1672.39	65228	39.00
June	36875	35.40	1521.14	59839	39.34
July	40225	38.62	1659.50	63951	38.54
August	32450	31.15	1338.52	51818	38.72
September	33000	31.68	1361.29	52059	38.24
October	42556	40.85	1755.32	67848	38.65
November	40250	38.64	1660.36	55351	33.34
December	44575	42.79	1838.77	69839	37.98
		452.05	19424.57	765337	

• Based on 0.96 sp. gravity for F. Oil. 18500 Btu/lb is heating valve of F.O = 42.97 GJ/M-T

PREMIER TOBACCO INDUSTRIES BOILER

Type of Boiler = Loco Type

No of Boilers = Two

One stand by (2000 lbs/hr)

Manufacturing date of boiler = 1945

Date of installed = 1972

Length = 20 Feet

Length of furnace = 7 feet

Breadth = 5.25 feet

Height = 6.75 Feet

Type of insulation = Good

Temperature of the Feed water = 140-160°F

Pressure (Rated) = 225 Psi

Presure (Operating) = 120-150 Psi

Capacity (Rated) = 6000 lbs/hr

Capacity (operating) = 5000-6000 lbs/hr

Heating Surface = 1000 ft^2

No of burners = One

The boiler being of the loco type could not be expected to have an efficiency greater than 65% in the best possible condition. Unfortunately actual readings could not be taken as no hole for flue gas analysis existed and the factory management did not permit a hole in the flue to be drilled. The efficiency had therefore to be estimated and bearing in mind operating conditions, the figure of 55% efficiency was assumed and the calculations are made on the basis of 55% efficiency.

It is estimated that if a new boiler is installed with efficiency 78%, then there will be fuel oil savings 124971.20 litres which will cost Rs.202453.344 and if the cost of the new boiler (second hand) is considered Rs.660000 then the payback period is 3.26 years. Therefore it is recommended that a new boiler should be installed with a provision that it can be operatable on Suigas/fuel oil.

PREMIER TOBACCO INDUSTRIES

INSULATION OF VALVE

No of Valves = 2

Dia = 6" approximately

Temperature of Steam = 175°C

Steam Pressure = 8 bar

Heat Lost = 1150 Watt

$$\text{Heat loss/year} = \frac{12 \times 3600 \times 1150 \times 300}{10^9}$$

$$= 14.9 \text{ GJ/year}$$

Heat lost from the two valves/year = 29.8 GJ/year

Cost of Energy = Rs.38.90/GJ

Saving = 29.8 x 38.9

= Rs.1159.22

If these valves are insulated then the payback period will be one year.

INSULATION

There are only two pipe lines of steam which found non insulated, their details are as under :

(a) Length = 10 feet (3m)
Dia = 1" (25 mm)

(b) Length = 10 feet (3m)
Dia = 0.5" (12.5mm)
Steam Pressure = 8 bar
Temperature = 175°C

Assume outside temperature of pipe as 150C

(a) Heat Loss = 3 x 280 = 840 Watt
(b) Heat Loss = 3 x 190 = 570 Watt

Total Heat loss = 1410 Watts

1 kwh = 3413 Btu

1 Btu = 1055.86 Joules

Heat Loss = 1410 Joules/Sec

$$= \frac{1410 \times 60 \times 60 \times 24 \times 300}{10^9}$$

= 36.54 GJ/year

Cost of GJ = Rs.38.90

= Rs.1421.40

If these pipe-lines are insulated than the pay back period will be one year.

PREMIER TOBACCO INDUSTRIES

Cut- Tobacco Store

Dry bulb Temperature = 27.4°C

Temperature Difference = 3.2°C

Room Temperature = 28.4°C

Size of Room = 30' x 60' x 15.5'

Humidity required = 74-76%

Humidity Calculated = 74%

Packing Section (Production Hall)

Size of Hall = 90' x 120' x 15.5'

Humidity required = 55-60%

Dry Bulb Temperature (i) 26.2 (ii) 26.6

Temperature difference = (i) 2.6 (ii) 3.5

Room Temperature = 25.2°C

Humidity Calculated = (i) 81% (ii) 74%

Humidity in cut-Tobacco store was found as per requirements. While great difference was noted in the packing section, here and humidity is recorded as 81% and 74% while the requirement is 55-60%

Inlet out side Temperature db = 30°C

Relative Humidity = 30%
Specific Volume = 0.86 Kg/m^2
Moisture Content = .008 Kg/Kg

Actual Inside Conditions

Dry Bulb temperature = 26.2

Wet Bulb temperature = 23.6

Difference = 2.6

Relative Humidity = 80%

Moisture Contents = 0.018 Kg/Kg

Required Inside Conditions

Relative Himidity = 60%

Moisture Contents at this humidity = .014 Kg/Kg

Assume normally 80% from cooler and 20% from

Steam. The moisture Contents in the air

= .014 - 008 = .006 Kg/Kg

Cooler gives = .0048 Kg/Kg

Steam gives = .0012 Kg/Kg

Leaving Cooler air contains = .008 + .0048 = .0128 Kg/Kg

Therefore .004 Kg/Kg too much added from Steam specific

Volume = .86 Kg/m^3

Volume of Hall = 51636 m^3

Then .86 x 10 x 51636 = 444069.6 Kg of air in assuming

10 air changes per hour, one hour 0.004 K/g of air from Steam

Steam provided = .004 x 444069.6 = 1776.2 Kg of Steam/Hour

Saving of steam/year = 1776.2 x 12 x 300

= 6394320 Kg of steam /year

The fuel oil has a value of 41131 Kg/l and at efficiency

of 55%, it will provide

= 41131 x .55 = 22622 KJ/l

Since Steam pressure = 120 Psi = 8 bar

Total heat in Steam = 2774 KJ/Kg

Heat in feed water = 40 x 4.187 = 167.5 KJ/Kg

Heat provided by the fuel oil = 2774-1675.5=2606.5 KJ/Kg

1 litre of oil will provide = $\frac{22622}{2606.5}$ =8.68 Kg of steam

Therefore the net saving of oil = $\frac{6394320}{8.68}$ = 736672.8 litre/yr

Saving in Rupees = 736672.8 x 1.62=Rs.1193409.9

Energy Saving = 30303 GJ

Cost of Energy = Rs.38.9/GJ

Total Saving = Rs.1178786.7

PREMIER TOBACCO INDUSTRIES ELECTRICITY

Month	Power Factor
January 1986	0.74
February 1986	0.74
March 1986	0.74
April 1986	0.74
May 1986	0.73
June 1986	0.73

RECOMMENDATIONS

Power factor measured was showing a result of .94, 96 and .47 while actual power factor comes out to be 0.74 and 0.73 this is a great discrepancy, which shows that there is some fault in the working of Capacitor bank. If it is rectified then the factory should save Rs. 36,000 per year which it has to be paid for low power factor.

PREMIER TOBACCO INDUSTRIES MANDARA
ELECTRICITY CONSUMPTION

Month	KWH	G.J.
January 85	73890	266.01
February	95480	343.73
March	57040	205.34
April	63510	228.64
May	96980	349.13
June	12470	44.89
July	99080	356.68
August	105510	379.84
September	105020	378.07
October	100920	363.31
November	113020	406.87
December	102080	367.48
Total	1025000	3690

PREMIER TOBACCO INDUSTRIES MANDRA

	GJ			
Fuel Oil	= 19424.57	$= \frac{19424.57}{23114.57} \times 100$	= 84.04%	$= 84.04 \times 3.6 = 302.54^{\circ}$
Electricity	= 3690	$= \frac{3690}{23114.57} \times 100$	= 15.96%	$= 15.96 \times 3.6 = 57.45^{\circ}$
Total	= 23114.57			

	RS.			
Fuel Oil	= 765337	$= \frac{765337}{1187437} \times 100$	= 64.45%	$= 64.45 \times 3.6 = 232.02^{\circ}$
Electricity	= 422100	$= \frac{422100}{1187437} \times 100$	= 35.54%	$= 35.54 \times 3.6 = 127.94^{\circ}$
Total	= 1187437			

PREMIER TOBACCO INDUSTRIES MANDARA

Tubes

Managerial Office Officer	32 = 32 x 40 = 1280 Watts
Canteen	
P.M.D.	92 = 92 x 40 = 3680 Watts
Engineering store	20= 20 x 40 = 800 watts
Material store	3 = 3 x 40 = 120 watts
Non duty paid Cigarette Godown	16 = 16 x 40 = 640 Watts
Engineering Workshop	26 = 26 x 40 = 1040 Watts
Boundary lights	
Canteen Mosque	23 = 23 x 40 = 920 Watt
Total	8480 Watt
Boiler Room	16 = 16 x 40 = 640 watt
Cigarette making and packing	200 = 200 x 40 = 8000 Watt
Total	8640 watt

Bulbs

1 = 1 x 250 = 250 Watt

8 = 8 x 250 = 2000 watt

12 hours works in a day 300 days in a year

5 = 5 x 200 = 1000 Watt

29 = 29x200 = 5800 Watt

9 = 9 x 200 = 1800 Watt

10850 Watts

Total 19330 Watt

=19.330 KW

=250.52 GJ/yr

2 = 2 x 250 = 500 watt

2 = 2 x 250 = 500 Watt

1000 Watt

24 hours work in a day 300 days in a yr.

Total = 9640 Watt

= 9.640 KW

9.640 KW

Total = 250.52 + 249.868

= 500.38 GJ/yr.

PREMIER TOBACCO INDUSTRIES MANDRA

RECOMMENDATIONS:

Detailed Energy Audit Survey of Premier Tobacco Industries, Mandra was conducted from March 31 to April 2, 1987. Necessary data was collected and process conditions at different sections were checked by using the latest.equipments/instruments available with the survey team of DGNRER. From these results and analysis made on the basis of the data collected, following recommendations are made :-

i) Consideration should be given to the replacement of Loco type boiler which is having lower efficiency by modern package type boiler which has a higher efficiency of 78% and capable of producing more steam.

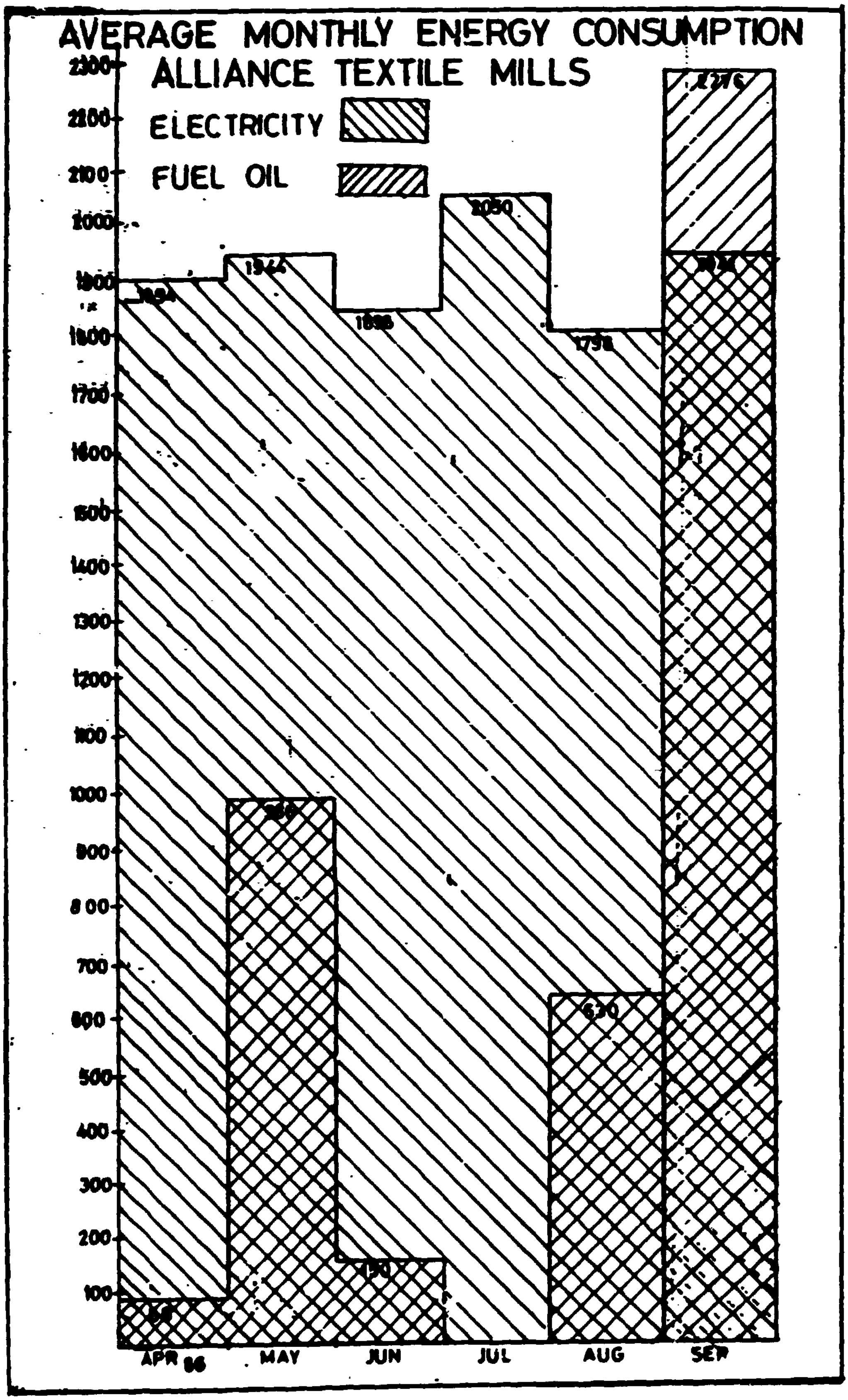
ii) Two valves of ¢ 6" approximately and 2 pipelines of steam of length 3 m each ¢ 25 mm and ¢ 12.5 mm respectively found non-installed. Heat loss from the valves are 29.8 GJ/yr and from pipes 36.5 GJ/yr. If these valves and pipelines are insulated then a saving of Rs.2580.62 per year can be saved and if these pipe lines and valves are properly insulated then the pay back period for insulation is one year only.

iii) Special attention is required towards the Humidity control in the packing Hall. It is required to control the steam in the packing Hall and steam flow should be reduced, the proper control of Humidity will save Rs.11,78,786.7 per year.

iv) Power factor measurements were made by the Power factor meter. The power factor readings were .96, .94 and .47 while the power factor from the bills collected is .73 to .74. It is much lower than required. Meter should be checked. A proper control on the capacitor bank will save Rs.36,000/- per year.

v) Water meters and fuel meters should be installed in the boiler section.

vi) An Energy Manager should be appointed who should look after the works relating to the energy in order to curtail the use of energy and to make efficient use of the available sources.


AVERAGE MONTHLY ENERGY CONSUMPTION
ALLIANCE TEXTILE MILLS
ELECTRICITY
FUEL OIL
2300
2200
2100
2000
1900
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
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100
1944
2050
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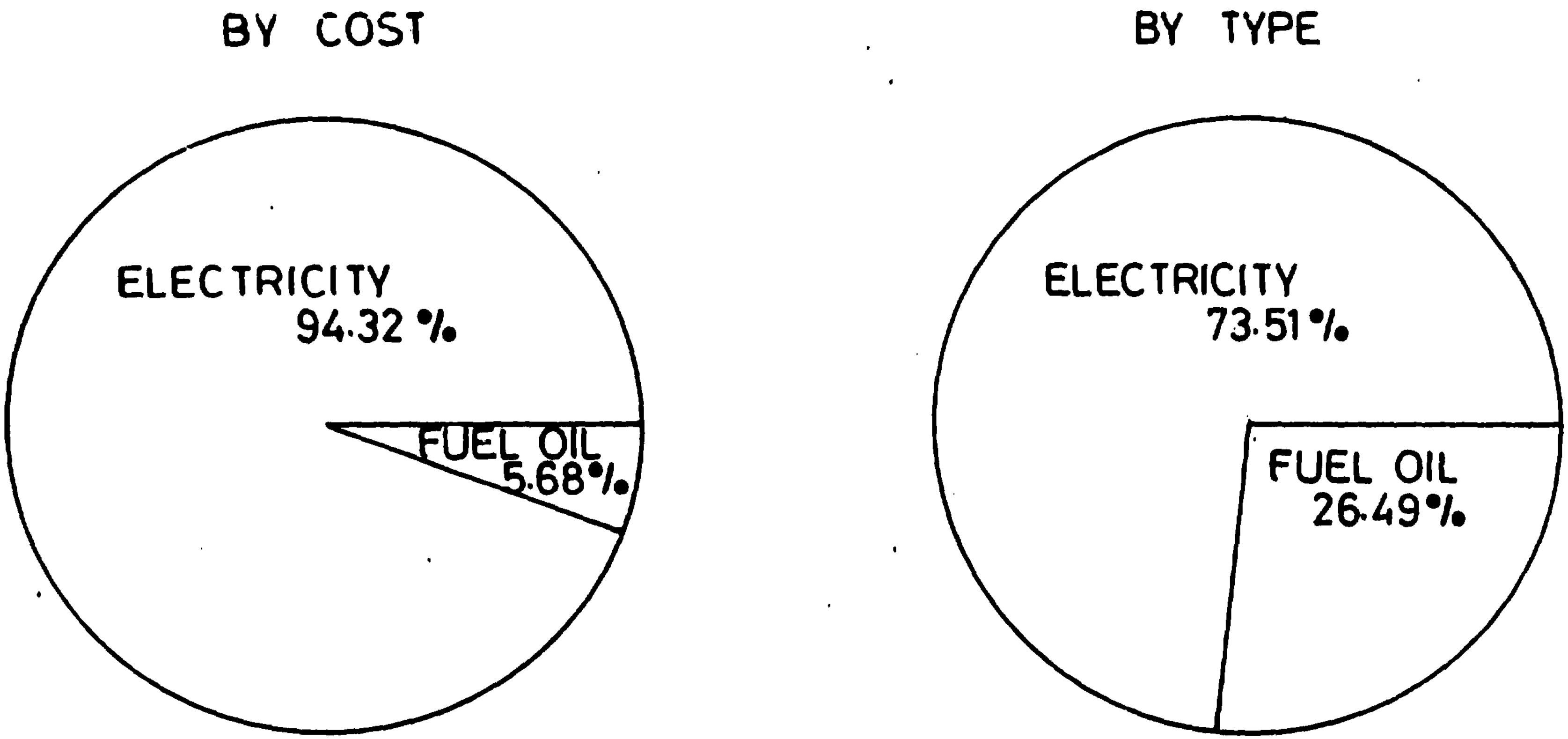
630
APR 86
MAY
JUN
JUL
AUG
SEP

ENERGY DISTRIBUTION



ALLIANCE TEXTILE MILLS LIMITED
BY COST AND BY TYPE OF ENERGY CONSUMED

BOILERS

ALLIANCE TEXTILE MILLS JHELUM

No: 3

Capacity = 7500 lbs/hrs

Type : Lancashire

Steam Pressure = 100-120 Psi

Safety Valve designed at = 150 lbs/m^2

Average Steam Pressure = 7.5 bar

Steam Temperature :- 173.02°C

Steam = 2771.7 KJ/Kg

Total Heat in Steam at 7.5 bar = 2771.7 KJ/Kg

Feed Water Temperature = 45°C

Heat in Feed Water = 45 x 4.187 = 188.415 KJ/Kg

Heat Provided by the fuel oil = 2771.7 - 188.415 = 2583.285 KJ/Kg

The fuel oil clorific value = 41131 KJ/l

1 Btu/lb = 0.43 KJ/Kg for Steam

Furnace oil = 18500 Btu/lb

418 items/ton ________ for oil

= 41,800,000 Btu/2,24016

= 18,660 Btu/lb

= 18660 x 2.2 Btu/Kg

= 41053.5 Btu/Kg

= 41053.5 x 1.05 KJ/Kg

= 43352 x 0.96 = KJ

Assuming 57% efficiency of the Boiler, The fuel oil will provide heat at 57% efficiency

= 41131 x .57 KJ/l

= 23444.67 KJ/l

and 1 litre of oil will provide steam:-

$= \frac{23444.67}{2583.285} = 9.075$ Kg of steam.

ALLIANCE TEXTILE MILLS LTD. JHELUM

STEAM DISTRIBUTION:

CONDENSATE LINE

Length = 516 feet = 157.276 meter

Dia = 3" = 75 mm

Ambient Temperature = 29C

Assuming Condensate at 90C°

Surface Temperature of pipe = 75 C°

Heat Losts/meter = 210 Watt

Length = 516 Feet

1 meter = 3.28084

$$= \frac{516}{3.28084} = 157{,}276 \text{ meter}$$

Heat Lost = 210 x 157.276

= 33027.96 Watts

Assuming 12 hours operation of boiler

$$\text{Heat Loss:-} \quad \frac{33027.96 \times 60 \times 60 \times 12 \times 300}{10^9} = 428.042 \text{ GJ/year}$$

At boiler efficiency of 57%

$$= \frac{428.042}{.57}$$

= 750.95 GJ/year

$$= \frac{750.95 \times 10^6}{41131} = 18257.51 \text{ liters}$$

1 liter of oil = 1.62

Total Saving = 18257.51 x 1.62

Rs. = 29577.1

Pay back period is one year

ALLIANCE TEXTILE MILLS LTD.

Detailed Energy use and costs

Month	Consumptions liters	Energy GJ	Total Steam producer (100%) Kg	Actual Steam Production	Steam at 78% efficiency Kg	Energy Saving in terms of steam Kg.
April 1986	2152	88.51	19530	11132.1	15233.4	4101.3
May	23902	983.11	216923.22	123646.23	169200.11	45553.88
June	3643	149.84	33062.14	18845.41	15788.46	6943.05
July	-	-	-	-	-	-
August	15288	628.81	138746.64	79085.58	108222.37	29136.79
September	55190	2270.00	500878.27	285500.61	390685.05	105184.44
	100175	4120.29	909140.80	518210.256	709129.824	190919.568

$$\text{Saving} = \frac{78-57}{78} = .269230$$

Month	Saving in fuel oil (litre)	Saving in Rs.
April 1986	579.38	874.86
May 1986	6435.15	9717.07
June 1986	980.80	1481.00
July 1986	-	-
August 1986	4115.99	6215.14
September 1986	14858.84	22436.84
	26970.19	40724.98

Saving in a year = 81449.97

Pay back period = 8.1 years

Month	Fuel oil saving (letter)	Saving in Rs.
April, 1986	451.90	682.369
May, 1986	5,019.42	7,579.32
June, 1986	765.03	1,155.1953
July, 1986	-	-
August, 1986	3,210.47	4,847.80
September, 1986	11,579.9	17,500.749
	21,036.74	31,765.47

Saving/year = 31,765.47 x 2 = 63,530.94

$$\text{Pay back period} = \frac{660{,}000}{63{,}530.94} = 10.38 \text{ years}$$

ALLIANCE TEXTILE INDUSTRY JHELUM ELECTRICITY

Month	Power Factor
February, 1987	0.96
January, 1987	0.96
December, 1986	0.96
November, 1986	0.96
October, 1986	0.96
September, 1986	0.95
August, 1986	0.95
July, 1986	0.94
June, 1986	0.95
May, 1986	0.94
April, 1986	0.94
March, 1986	0.93
February, 1986	0.94
January, 1986	0.95

ALLIANCE TEXTILE MILLS LTD. JHELUM

Electricity Consumption

Month	KWH	G.T
April, 1986	5260,020	1893.67
May, 1986	540,030	1944.11
June, 1986	510,540	1837.94
July, 1986	569,550	2050.38
August, 1986	499,410	1797.87
September, 1986	539,250	1941.30
Total:	3184,800	11465.27

ALLIANCE TEXTILE MILLS LTD. JHELUM

FUEL OIL CONSUMPTION

Month	Litres	M.T.	G.J.	Cost	Rs/G.T	
April, 1986	2152	2.06	88.52	3443.20	38.89	
May, 1986	23902	22.95	986.16	36564.80	37.08	
June, 1986	3643	3.50	150.39	7507.20	49.92	
July, 1986	-	-	-	-	-	
August, 1986	15288	14.67	630.40	17748.80	28.15	
September, 1986	55190	52.98	2276.5	86475.60	37.98	
Total:		96.16	4132.02	151739.60	38.41	average for 5 month

* Based on 0.96 sp. gravity for Fuel Oil, 18500 BTU/lb is heating value of Fuel Oil = 42.97 G.J/M-T

ALLIANCE TEXTILE MILLS LTD.

	Tubes	Bulbs
Electric Workshop	8 = 8x40 = 320 Watt.	
Softening & Personel Office	6 = 6x40 = 240 Watt	1 = 1x100 = 100 Watt.
Laboratory	17 = 17x40 = 680 "	Total 100 Watt.
Godown	5 = 5x40 = 250 "	
Main Office	99 = 99x40 = 3960 "	
Reception+Gate Office + Excise Office.	6 = 6x40 = 240 "	
	Total = 5640 Watt.	
	Total = 5.740kWatt	

8 hrs. in a day
300 day in a year. } = 5.740x.0036x8x300KW/hrxGJxhr/dayxday/year

= 49.59 GJ/Year.

	Tubes	Bulbs
Workshop	18 = 18x40 = 720 Watt	
Packing section	32 = 32x40 = 1280 "	
Water Tank	2 = 2x40 = 80 "	
Colony Street light	50 = 50x40 = 2000 "	
Factory Boundry wall	27 = 27x40 = 1880 "	
Club+Gest House+Officer+ Banglow	46 = 46x40 = 1840 "	288 = 288x100 = 28800 Watt.
Officers Colony		1081 = 1081x100 = 108100 "
Total	7000 Watt	Total = 136900 Watt.

G.Total = 143900 Watt.

12 hours in a day
300 days in a year } =

143.900x12x.0036x300 = 1864.94 GJ/Year

ALLIANCE TEXTILE MILLS LTD. JHELUM

Canteen Lower Staff	19 = 19 x 40 = 760 Watt	
Boiler House	3 = 3 x 40 = 120 "	2 x 10 = 200 Watt
Time office, Gate office	4 = 4 x 40 = 160 "	
Dyeing + Bleaching + Finishing + Wearing	226 = 226 x 40 = 9040 Watt	
Preparatory + Spinning + Cone making	230 = 230 x 40 = 9200 Watt	
Carding + Blue Room + Power House	136 = 136 x 40 = 5440 Watt	
Fire room	5 = 5 x 40 = 200	
	Total: 24290 Watt	Total: 200 Watt

G. Total: 25120 Watt

24 hours in a day }
300 days in a year } = 25.120 K Watt

25.12 x .0036 x 24 x 300 = 651.11 G.J/year

Total lighting in a year = 651.11 + 1864.94 + 49.59 = 2565.64 G.J/yr

ALLIANCE TEXTILE MILLS LTD. JHELUM

Main Office	1½ ton.
Club	1½ ton.
Resident Director	1½ ton.
Chief Executive Residence	1½ ton.
Resident Director Residence	1½ ton.
Mill Manager Residence	1½ ton.
Technical Adviser Residence	1½ ton.
G.H. Finance	1½ ton.
Laboratory	1½ ton.
Mill Manager Office	1½ ton.
for C.O.P (Co-efficent of Performance) is	2.5 : 1

1 for of Refrigeration = 200 BTU/mm

or = 200 x 60 = 12,000 BTU/hour
so for C.O.P. of 2.5 = 12000 BTU/hour: 4800 BTU/hour
for 1½ ton = 6000 BTU/hour
= 10 BTU/hour = 3 W
so = 600 x 3 = 1800 Watt
= 1.800 K Watt for 1½ ton A.C.
for 10 Nos A.Cs = 1.800 x 10 = 18 K Watt

8 hours in a day)
300 days in a year) = 18 x 8 x 300 x .0036 = 155.52 GJ/year

ALLIANCE TEXTILE MILLS LTD. JHELUM

GJ

Fuel Oil = 4132.02 $= \frac{4132.02}{15597.29} \times 100 = 26.49\% = 26.49 \times 3.6 = 95.36^{\circ}$

Electricity = 11465.27 $= \frac{11465.27}{15597.29} \times 100 = 73.51\% = 73.51 \times 3.6 = 264.64^{\circ}$

Total = 15597.29

Rs.

Fuel Oil = 151739.60 $= \frac{151739.60}{2672170} \times 100 = 5.68\% = 5.68 \times 3.6 = 20.45^{\circ}$

Electricity = 2520431 $= \frac{2520431}{2672170.60} \times 100 = 94.32\% = 94.32 \times 3.6 = 339.55^{\circ}$

Total = 2672170.60

ALLIANCE TEXTILE MILLS LTD - JHELUM

RECOMMENDATIONS

Detailed Energy Audit Survey of Alliance Textile Mills, Jhelum was conducted from April 5 to April 9, 1987. Necessary data was collected and process conditions at different sections were checked by using the latest equipments/instruments available with the survey team of DGNRER. From these results and analysis made on the basis of the data collected, following recommendations are made :-

i) Replacement of the boiler with the Package type boiler.

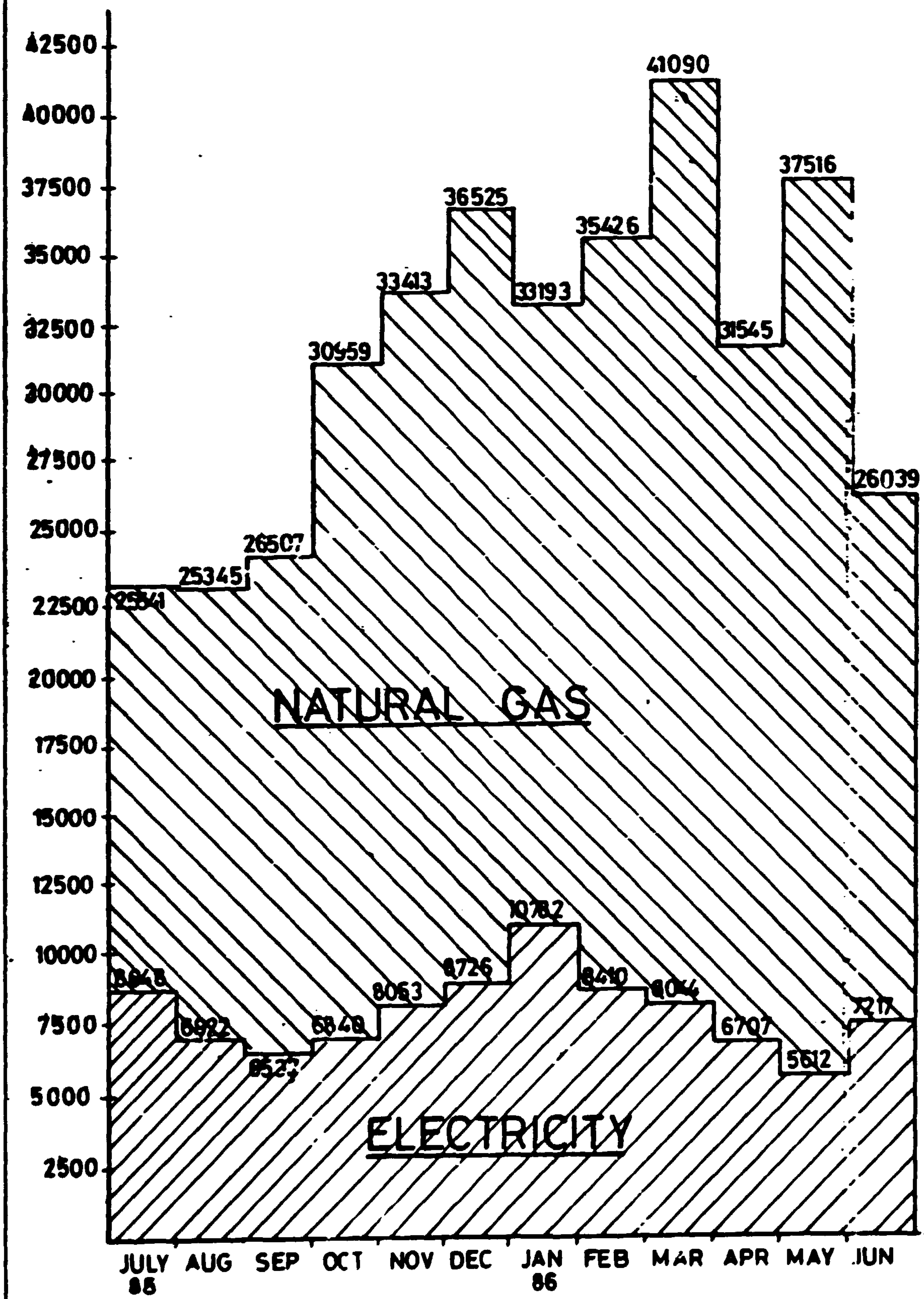
ii) Installation of fuel meter and water meter in the boiler section.

iii) Condensate line from the wet processing section to boiler section should be insulated. Analysis shows that due to unlagging of this pipeline energy equivalent to 750.95 GJ/yr is dissipated into the atmosphere. If it is properly insulated then a saving of Rs.29,577.1 can be made in a year and the pay back period for this insulation will be one year only.

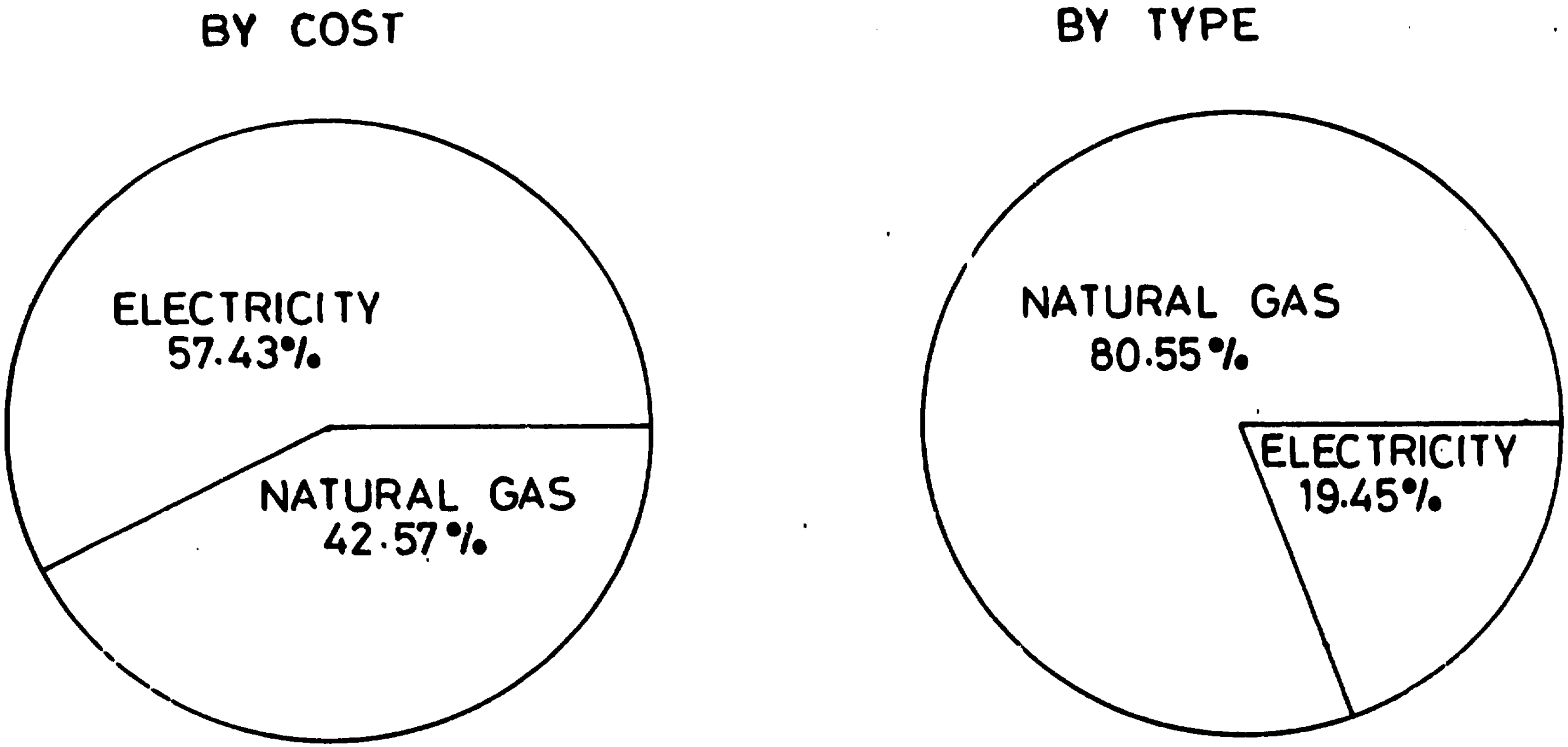
iv) An Energy Manager should be appointed who should be responsible for all matters relating to the energy in order to curtail the use of energy and make efficient use of the available sources.

v) General house keeping and maintenance should be maintained in each section especially in simplex, carding, blow room and spinning sections as the dust and cotton fluff adhere to the motors and there is chance of motor flashing, so these should be cleaned on half an hour basis.

AVERAGE MONTHLY ENERGY CONSUMPTION
HEAVY FORGE AND FOUNDRY



ENERGY DISTRIBUTION



HEAVY FORGE AND FOUNDRY
BY COST AND BY TYPE OF ENERGY CONSUMED

HEAVY FOUNDRY AND FORGE

NATURAL GAS CONSUMPTION

Month	Consumption HM^3	Rate Rs./HM^3	Amount	Energy GJ
July 85	6989.634	140.36	981185.55	25537.8
August	6936.094	"	973670.11	26503.55
September	7253.954	"	1018285.03	26503.55
October	8472.295	"	1189291.34	30957.37
November	9143.951	"	1283564.94	33408.97
December	9995.454	"	1402961.923	36520.09
January 86	9083.856	"	1275130.00	33189.41
February	9694.812	"	1360883.86	35421.64
March	11244.738	"	1578431.42	41084.56
April	8632.661	"	1211800.31	31540.89
May	10266.821	"	1441171.00	37511.57
June	7126.037	"	1000330.55	26036.18
July	7157.172	"	1004700.00	26149.94
August	7631.750	"	1071331.00	27883.89
September	8405.342	"	1179893.00	30710.34
October	10072.651	"	1413917.00	36802.14
November	8165.767	"	1146267.00	29835.01
December	11858.857	"	1664629.00	43328.35
January 87	9619.135	"	1350216.00	35143.14
February	8062.130	"	1131712.00	29456.36
Total	175813.11	"	24677128.82	642363.08

STEAM DISTRIBUTION

HEAVY FOUNDRY AND FORGE

Ambient Temperature = 31°C

Valve Temperature = 120°C

i) Valve size 10" (250mm) dia

Loss of Energy = $\frac{900 + 1800}{2} = \frac{2700}{2}$ = 1350 Watts/Meter

= 1350 Watts/Valve

ii) Valve size 125 mm dia

Loss Energy = $\frac{500 + 1000}{2} = \frac{1500}{2}$ = 750

iii) Valve size 80 mm dia

Loss of Energy = $\frac{680 + 340}{2}$ = 510

= 510 Watts/Meter

iv) Two Valve of 200 Milimeter

Loss of Energy = $\frac{750 + 1500}{2}$

= 1125 x 2 = 2250 Watts/Meter

v) Valve size of 100 mm diameter

Loss of Energy = $\frac{420 + 830}{2}$ = 625 Watts/Meter

i) Size Dia = 125 mm

Loss of Energy = $\frac{500 + 1000}{2} - \frac{1500}{2}$ = 750 = 375 Watts

ii) Size = 175 mm dia

Loss of Energy = $\frac{700 + 1350}{2 \times 2}$ = 512.5 = 512 Watts

iii) Dia = 1.5 "

Loss of Energy = 200 + 400 = 150 Watts

Total heat lost from the Valves = 1350+750+510+2250+625

= 4360 Watts

Assume 12 hours running of the boiler

$$= \frac{4360 \times 60 \times 60 \times 12 \times 300}{10^9} = 56.50 \text{ GJ/year}$$

Total Heat lost from the Flanges = 375+512+150

= 1037 Watts

$$= \frac{1037 \times 60 \times 60 \times 12 \times 300}{10^9} = 13.43 \text{ GJ/year}$$

Total Heat Lost = 56.50 + 13.43 = 69.93 GJ/year

At boiler efficiency of 80%

$$= \frac{69.93}{.8} = 87.41 \text{ GJ}$$

Calorific Valve of Sui Gas = 980 Btu/ft^3

Rs.140.36 for HM^3

1 m^3 of Natural Gas = .03654165 GT

$$\text{Total Sui Gas Saving} = \frac{87.41}{.03654165} = 2392.06 \text{ m}^3$$

$$\text{Energy Cost} = \frac{39.54 \times 10^6}{980000 \times 1.055} \quad \text{Rs.}38.24/\text{GJ}$$

Total Saving = 87.41 x 38.24 = Rs.3342.55

Pay back period is one year.

H cuft = 1000 cuft

Rs.39054 for 1000 cuft

HCV of 1 cuft = 980 Btu

1000 cuft = 980,000 Btu

= 980,000 x 1.055 KJ

$$= \frac{980{,}000 \times 1.055}{10^6} \text{ GJ}$$

$$\text{Rs/GJ} = \frac{39.54 \times 10^6}{980{,}000 \times 1.055} = 38.24$$

POWER FACTOR

HEAVY FOUNDRY AND FORGE TAXILIA AND HEAVY MECHANICAL COMPLEX

ELECTRICITY

Month	Power Factor
July, 1985	0.88
August, 1985	0.88
September, 1985	0.89
October, 1985	0.89
November, 1985	0.92
December, 1985	0.94
January, 1986	0.92
February, 1986	0.92
March, 1986	0.90
April, 1986	0.88
May, 1986	0.87
June, 1986	0.87
July, 1986	0.85
August, 1986	0.86
September, 1986	0.86
October, 1986	0.86
November, 1986	0.91
December, 1986	0.92
January, 1987	0.90
February, 1987	0.89

HEAVY FORGE AND FOUNDRY TEXTILE

ELECTRICITY CONSUMPTION

Month	KWH	GJ
July 85	2402240	8648.064
August	1922880	6922.368
September	1815840	6537.024
October	1900160	6840.576
November	2237120	8053.632
December	2424000	8726.400
January 86	2995200	10782.720
February	2336320	8410.752
March	2234560	8044.416
April	1863200	6707.520
May	1559040	5612.544
June	2004800	7217.280
Total		92503.296

HEAVY FORGE AND FOUNDRY TAXILA

GJ

Electricity = 92503.296 = $\frac{92503.296}{475607.14} \times 100 = 19.45\% = 19.45 \times 3.6 = 70.02^{0}$

Natural Gas = 383103.850 = $\frac{383103}{475607.14} \times 100 = 80.55\% = 80.55 \times 3.6 = 289.98^{0}$

Total = 475607.14

Rs.

Electricity = 19852794 = $\frac{19852794}{34569620} \times 100 = 57.43\% = 57.43 \times 3.6 = 206.75^{0}$

Natural Gas = 14716826.08 = $\frac{14716826}{34569620} \times 100 = 42.57\% = 42.57 \times 3.6 = 153.25^{0}$

Total = 34569620

HEAVY FOUNDRY AND FORGE, TAXILA

RECOMMENDATIONS:

Preliminary Energy Audit Survey of Heavy Foundry and Forge Taxila was conducted from April 12 to April 14, 1987. Necessary data was collected and process conditions at different sections were checked by using the latest equipment/instruments available with the survey team of DGNRER. From these results and analysis made on the basis of the data collected, following recommendations are made:-

i) The meters installed at boiler house should be repaired immediately.

ii) An Energy Manager should be appointed who should be responsible for all the matters relating to the energy in order to curtail the use of energy make efficiency use of the available sources.

iii) It was ooserved that six various valves of sizes 250 mm, 200 mm (2 valves) 125 mm, 100 mm and 80 mm ⌀ were found non insulated while 3 flanges of size 175 mm, 125 mm, and 1.5" each were found non insulated. The analysis shows that heat lost from these valves and flanges are equal to 87.41 GJ/yr which is costing Rs. 3342.55. If these valves and flanges are properly insulated then this can save Rs. 3342.55/year and the pay back period for insulation of these valves and flanges will be one year only.

iv) Discharge valves installed on the various Hammers should be closed when these are not in operation.

v) Special attention should be given to the general cleanliness and house keeping.

vi) Consideration should be given to the replacement of existing burner to the modern burners of recuperative type which are automatically controlled.