PRODUCTIVITY LINKED ENERGY CONSERVATION

Thesis submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF ENGINEERING IN MECHANICAL ENGINEERING

(INDUSTRIAL ENGINEERING)

of BHARATHIAR UNIVERSITY

By

A. SHANMUGANATHAN

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Under the Guidance of

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KUMARAGURU COLLEGE OF TECHNOLOGY COIMBATORE 1984

CHARACTER IS LIFE

DEPARTMENT OF MECHANICAL ENGINEERING

KUMARAGURU COLLEGE OF TECHNOLOGY

(Affiliated to Bharathiar University)

COIMBATORE – 641 006

1999 - 2000

CERTIFICATE

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Certified that this is a bonafide report of thesis work done by

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During the year 1999 – 2000

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Submitted for viva-voce examination held at
Kumaraguru College of Technology on 30-12-2000

Internal Examiner

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CERTIFICATE

This is to certify that this thesis work entitled **PRODUCTIVITY LINKED ENERGY CONSERVATION** being submitted by **Mr. A. SHANMUGANATHAN** (Reg.No.9937H0010) for the award of the degree of **MASTER OF ENGINEERING (INDUSTRIAL ENGINEERING)**, is a bonafide work carried under my guidance. The results embodied in this thesis have not been submitted to any other university or Institute for the award of any Degree or any Diploma.

....

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This is to certify that Sri **A. SHANMUGHANATHAN**, Final Semester M.E. Industrial Engineering Student of Kumaraguru College of Technology, Coimbatore has successfully carried out the assignment of Project work entrusted to him at the Polyester X-Ray Plant of this Organisation.

Title of the Project : **PRODUCTIVITY LINKED ENERGY CONSERVATION AT POLYESTER X-RAY PLANT.**

Period of the Project work : **June 2000 to December 2000**

During the period of his Project work in this Plant, his attendance, conduct and character were found to be **GOOD**.

I wish him well in all his endeavours and a bright future.

(T.B. BHEEMARAJ)
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TO

MY BELOVED PARENTS

ACKNOWLEDGEMENT

The author wants to thank the dignitaries, whose efforts provided this opportunity to him with the entire boost. These dignitaries were Dr.K.Padmanaban, Principal, KCT, Coimbatore, Dr.A.Mohanakrishnan, HOD, Mechanical Department, KCT, Coimbatore, Dr.E.Vallinayagam, Professor, Post Graduate studies Mechanical, KCT, Coimbatore.

G.KARUPPUSAMY BE., (Hons)., M.E., Sr.Lect., (Mech), K.C.T., Coimbatore, the guide provided the author with the time, inspiration guidance and support that brought this thesis to completion.

Mr. Balasubramaniam, Manager, Tech, Research Centre, PXP, Ooty, the external guide gave the author his great time and suggestions which built him confident to go on with this project.

Then there was a group of people that the author called upon for clarification Mr. K. Selvaraj, Manager, Utilities, J. Rajkumar Deputy Manager, Coating, R. Ramesh A.M. Utilities, S. Lakshmi Narasimhan, Sr. Manager, Electrical.

The author thanks the family members who gave mental support to complete this project.

The author will try his best to hold his feelings for the above for ever.

SYNOPSIS

The polyester based x-ray project (RXP) had started its production independently from January 1997.

Since the products produced here are photo-sensitive all production process starting from raw materials to the finished products are carried out in safe lights (Dark room). The various process involved here are emulsion, coating and conversion. For the successful operation of these three departments it becomes essential for an additional department called as utility department.

Utility department provides the necessary conditions such as temperature conditions, Relative humidity, distilled water, hot water, cold water, etc to the place where it is needed. Hence without utility department the other departments cannot function.

Also, as polyester x-ray project is a fully automized project and is designed for 100% capacity utilization, it becomes very difficult to reduce the usage of utility department from 100% to less percentage if the percentage of production becomes less. Say, for example, even though if the percentage of production is 60% the utility department will operate at 100%. Hence there will be a loss of 40% capacity of utility department.

For more than a year as the company's production capacity is very less around 15%, 85% of energy is wasted from utility department as it is functioning at 100% capacity. Hence the work given to me is to reduce this 85% of energy losses to the company which leads to increase in productivity. Hence attempt has been made in different areas like rectifying and reducing idle running of Machines, pumps, blowers, etc., process modifications, rescheduling to achieve good co-ordination between each departments, reducing over usage of electricity, etc., which are given in the chapters to come.

CONTENTS

1. INTRODUCTION

Hindustan photo films the indigenous photographic industry was born in 1960. Commencing its commercial production in June 1967, the company has the proud privilege of having played a significant role in successful development of the vital photographic industry.

HPF was manufacturing Black and white cine films, photographic papers and acetate based medical x-ray film right from its inception in the sixties. During the seventies the black and white film products started losing ground to cine colour film and colour paper and acetate based x-ray film in the market.

The feasibility report for polyester x-ray project (PXP) was submitted on May1984 with a facility to manufacture medical x-ray, Industrial x-ray and graphic arts films with a capacity of 12 million square meters in collaboration with M/s. DUPONT of USA for a state of art technology.

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2. ENERGY SCENARIO IN INDIA- AN OVERVIEW

High rates of inflation combined with social justice against a backdrop of ever increasing population, this is the challenge which the government of India is facing today. It is evident that the annual growth rate of 5.6% as envisaged for the viii plan can never be met unless conscious efforts are made to augment Energy supplies by Energy Demand Management through energy conservation. In this context, a review of the energy – consuming sector in terms of their consumption trends, energy efficiencies or intensities, energy conservation opportunities, technologies used, energy investment programmes – would prove useful and informative.

2.1 MAJOR ENERGY USERS

2.1.1. <u>CONSUMPTION PATTERN</u>

In India, a siezeble portion of the energy need is met by non-commercial or traditional sources(refer fig.1) about 77% of the population is rural based and their consumption broadly falls into the pattern shown in figure 2a and figure 2b.

The industrial, agricultural, transport and domestic/ commercial sectors of the economy are the major consumers of the commercial energy source in india. Figure 3(a) presents the trends in the consumption of commercial energy in our economy, which figure 3(b) presents the primary energy balance.

2.1.2 ENERGY INTENSITY

Energy intensity in India leaves much to be desired in the various sectors of our economy. That "Energy efficiency improvements" is the most attractive route for economic growth is aptly brought out when one considers the following:

"At the present level, per capita consumption of electricity is around 230 units compared to the figure of 16522 units in Canada in 1985. Considering that the energy use efficiency in India, on the whole is about 50% of Canada, our T&D losses are 22% and 30% of gas produced is flared off the effective per capita consumption of electricity is only around 115 units, and without planning for improvements in energy efficiency, the envisaged per capita electricity consumption of 512 units by 2000 AD would mean an effective consumption of only 256 units."

2.1.3. SPECIFIC ENERGY CONSUMPTION:

The specific energy consumption (SEC) is used here as an indicator of the energy end-use efficiency. Table 1 presents the SEC's of important manufacturing sub sectors of the indian industry, as well as the Indian transport industry. Where figures are available, a comparison has been made with other countries. In the agricultural sector, it is reported that pumpsets in India consume 25%-30% more than the normal values.

2.1.4 ENERGY CONSERVATION POTENTIAL:

The specific energy consumption figures from table1 indicate the scope for improving the energy efficiencies. Various energy audit studies by several agencies have brought out the energy conservation potential. Notable among these studies are
(i) the IMWC study of 1980-82 (ii) the fuel oil utilisation studies by PCRA and NPC
(iii) the DOP sponsored energy audits of 10 manufacturing sectors of Indian industry conducted by the NPC in 1989 (iv) the studies by ICM, PCRA, NABARD and energy development agencies such as TEDA.

Tables 2a, 2b, 2c and 2d provide an overview of the estimated potential for conserving energy in the industrial, transport and agricultural sectors of the indian economy. The tables also provide an estimate of the investments required to implement various energy conservation measures in the particular sector.

Table 3 sums up a quantification of the energy conservation potential to industry and transport by various short term, long term and medium term measures, as recommended by the IMWG.

The most notable aspect of the various estimates for achieving energy conservation in india industry is that "Investments for a 15% saving pay back in a year, a 25% cut in energy bills takes 4 times the capital expenditure but evens out in four years, which means the effort is worth it"

Medium and loing term energy conservation opportunities, most often involves the induction of energy efficient technologies. A list of these technologies is presented in Table 4.

AID PROGRAMMES TO PROMOTE ENERGY EFFICIENCIES

A survey by FICCI undertaken in 1989 brought out several constraints faced by industry in achieving the energy conservation potential. Table 5 presents the results.

It can be seen that non availability of finance (35%) inadequate information (25%) dearth of consultancy services (30%) and lack of trained man power (30%) are some of the major reasons resulting in non-quantitication of risks, that have stymied the implementation of Energy Conservation programmes in the country.

Several programmes, including the ones pertaining to financial and hardware support have been structured and implemented in the country they are listed below:

- A nodal agency EMC to co-ordinate various programmes in the country.
- UNDP and EEC Energy Bus projects at Ahmedabad, Delhi, Calcutta, Madras, Bangalore, Kanpur, Pune.
- Energy audit subsidy and energy efficient equipment finance schemes of the IDBI.
- The Energy Management Consultancy and Training Programme (EMCAT) sponsored by USAID.

- PACIR scheme of the ICICI
- Energy audit subsides of Energy Development Agencies Electricity Boards.
- Training and Awareness Programme of NPC, PCRA.

2.2 STATUS OF ENERGY CONSERVATION IN INDIA

The status of energy conservation in India is best brought out in a compendium-Energy Conservation the Indian experience published by NPC. The salient features are listed below:

- Energy conservation as a movement in India began much earlier to the oil crisis of 1974.
- The fuel efficiency services of NPC and the PCRA were fore-runners to propogating energy management in the country.
- A number of industries both public and private sectors have been successfully implementing energy saving measures to match the best performances that are possible within the limits of their technology. These studies have been well documented.
- There still remains considerable potential to enhance energy efficiencies. Some of the barriers of consultants to speedier implementation of energy conservation programmes include (i) lack of awareness, (ii) lack of legislations. (iii) lack of demonstration projects and third party financing. (iv) lacunae in training, (v) inadequate financial and technical inputs.

** A number of governmental and private (associations, Universities, R&D setups) programmes have been established to overcome some of the above barriers. These have already been listed earlier.

- It is a strong desire of the government that the long-term objectives of a 15% reduction in overall specific energy consumption by 1994 – 95 and a 30% reduction by 2000 AD (base year 1988 – 89) be brought about by a cohesive policy by demonstration/training.

2.3 MODEL/DEMONSTRATION PROGRAMMES

As discussed earlier two key barriers to accelerated realisation of the energy conservation potential have been (i) finance and (ii) undemonstrated potential resulting in an uncertainty about the risks involved.

The working document for the VIII Five Year Plan has stressed the need for the foundation and execution of government sponsored Model or Demonstration Projects in various sectors of the economy. These programmes would aim at

- Encountering resistance of industries/organisations to try newer/emerging technologies and innovation in the area of energy conservation.
- Generate useful information base on the performance of these technologies which can then be selectively diseminated among professional interests.

- The selection of projects / sites may be done by an advisory committee suitably represented by professionals, R&D community, user industry, equipment manufacturers, financial institutions and governed by guidelines which include constant review.

The model/demonstration projects scheme is envisaged to work in three stages.

Stage 1 – Short – term: Preparatory work – inviting proposals, prioritising various programmes – establishing proper linkages with R & D institutions for optimum results and drawing up of a detailed plan of action which include project periods (schedules), implementing agencies, monitoring agencies and reporting procedures.

Stage 2 – Mid-Term: In the medium – term (2-5 year time frame) projects which have well been demonstrated in the other countries or where the exploratory work has been completed by the beneficiaries or implementing agencies may be taken up.

Stage 3 – Long-term: This stage involves exploratory pilot plant studies and may be planned in conjunction with the Department of Science and Technology or other R&D Institutions.

WHAT IS NEEDED

We then need to know the following:

- Energy efficiency should be demonstrated – this involves demonstration of the concepts and the technologies.
- The sectors where a particular technology or scheme can result in energy saving. Table 6 is one such summary.
- Extent of technology transfers that is involved and the funds for technology development foreign exchange import procedures patents.
- Requirement of other resource-trained engineers, technicians and consultants.

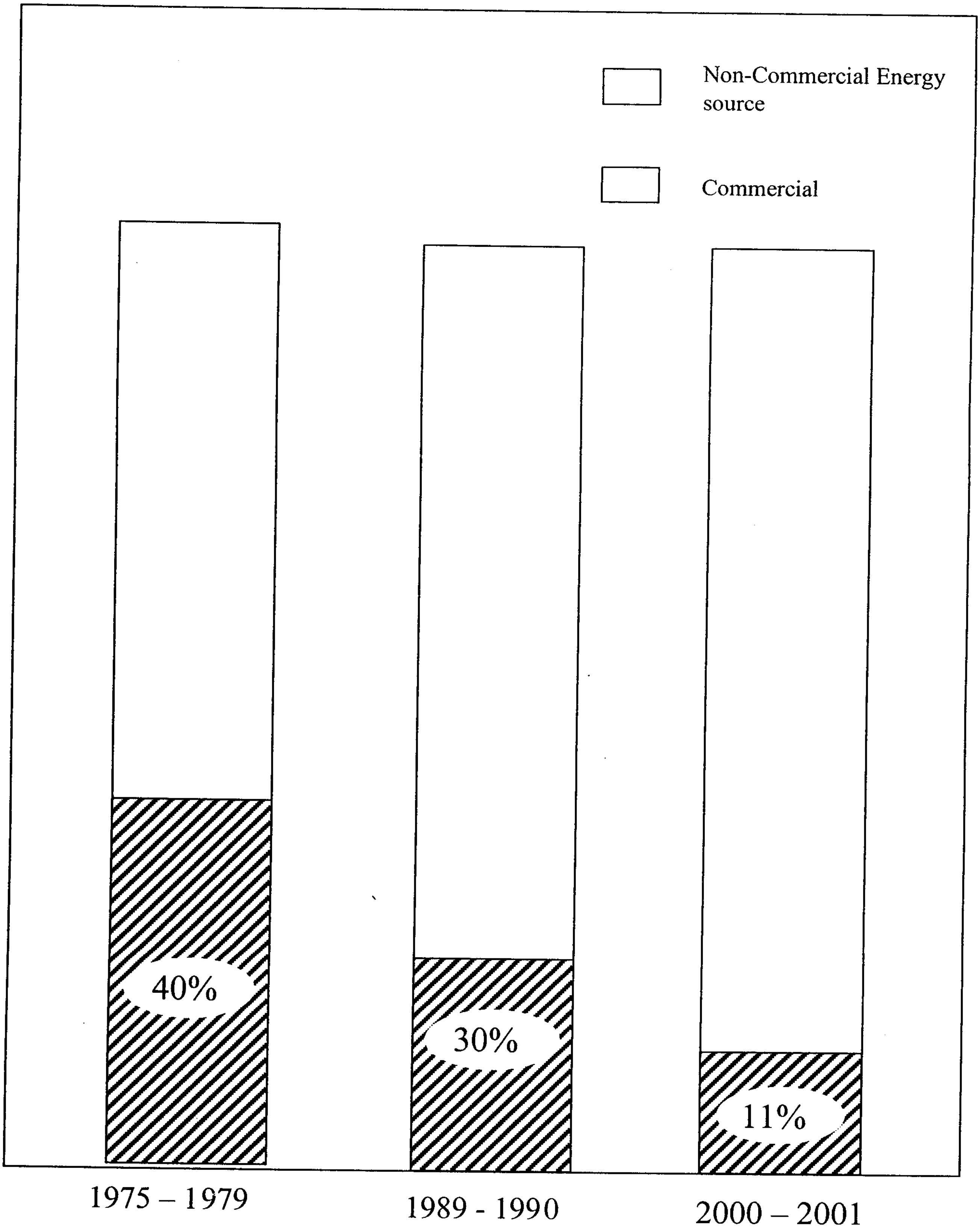


FIGURE 1- ENERGY CONSUMPTION TRENDS IN INDIA

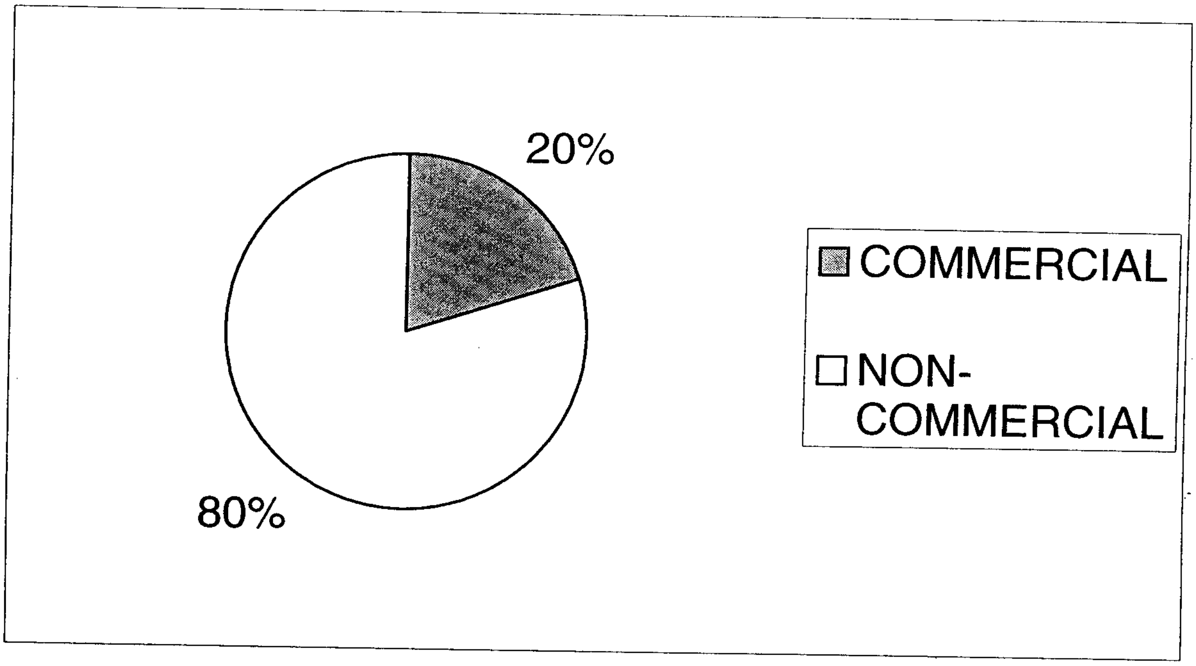


Fig.2A Energy Consumption pattern in Rural India

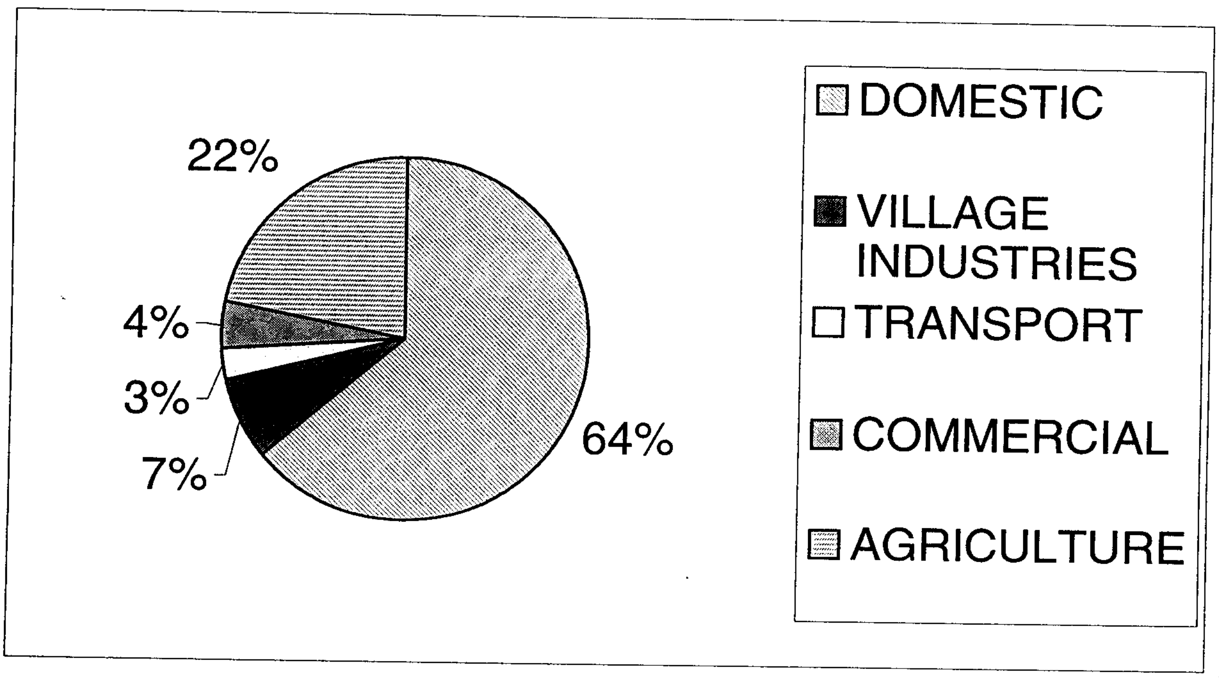


Fig.2B Energy Consumption in Rural India by use

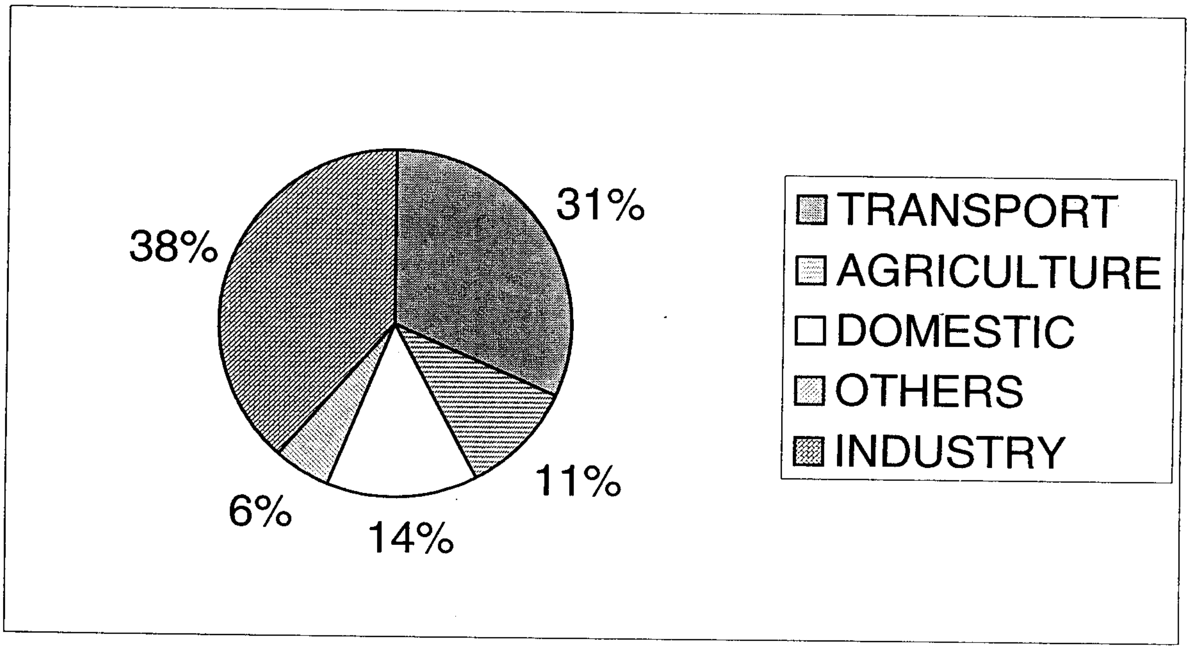


Fig.3B Commercial Energy Balance for India

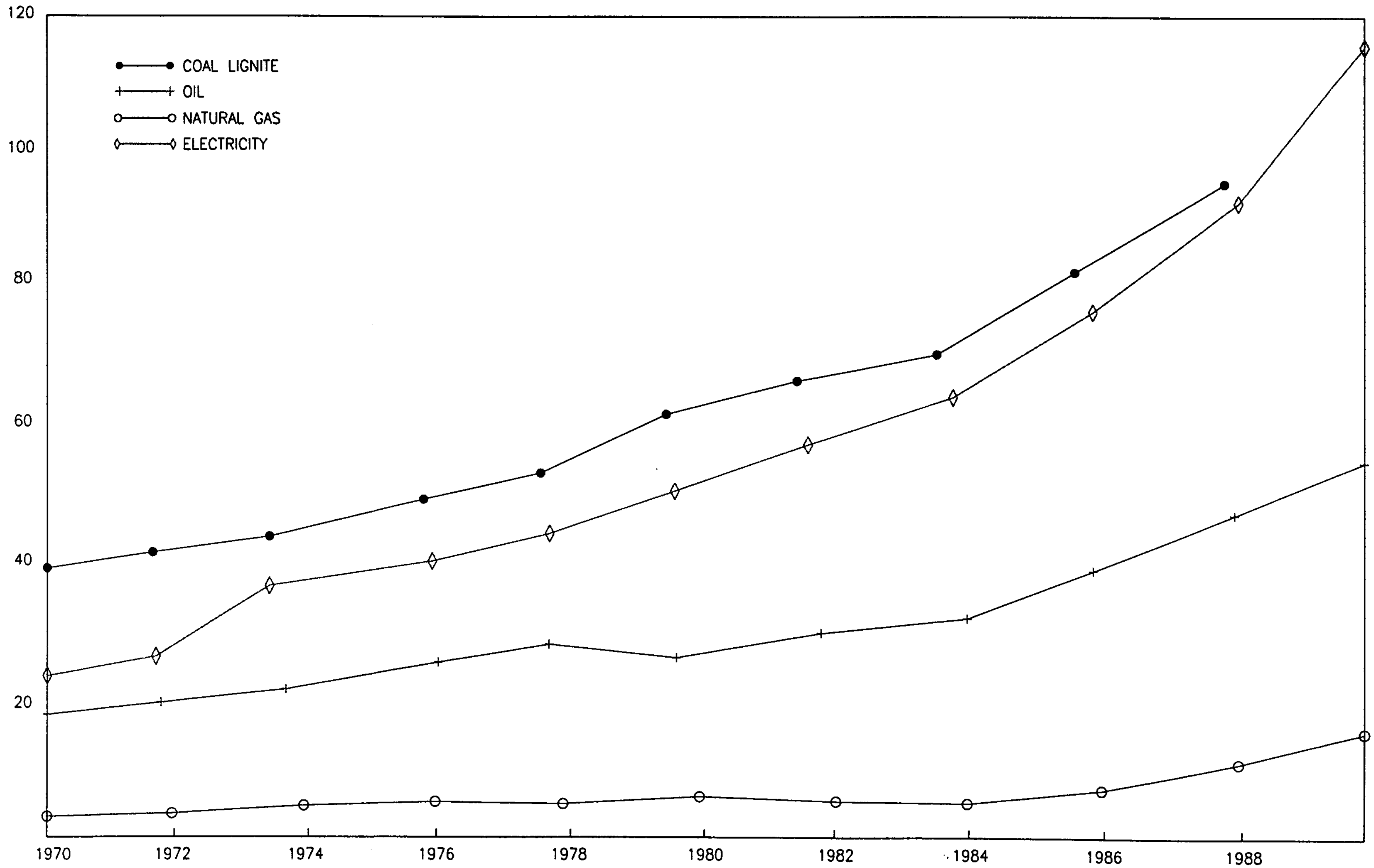


FIGURE 3a – COMMERCIAL ENERGY CONSUMPTION IN INDIA

TABLE 1

SPECIFIC ENERGY CONSUMPTION (Mkcal/Tonne)

COUNTRY	STEEL	CEMENT	PULP & PAPER	FERTILISER	TRANSPORT		
					RAIL		ROAD
					MG	BG	
INDIA	9.50	2.00	11.13	11.25	46.4	24.2*	4.21
JAPAN	4.18	1.20	----	----	69.9	50.0**	
SWEDEN	5.02	1.40	7.56	----			
U.K	6.07	1.30	----	7.62			
U.S.A	6.06	0.95	9.70	11.32			
GERMANY	5.21	0.82	----	----			
ITALY	4.03	0.89	----	9.92			

* GOOD TRANSPORT

** PASSENGER TRANSPORT

TABLE 2A

POTENTIAL ENERGY SAVINGS IN INDUSTRIAL SECTOR

INDUSTRIAL SECTOR: CONVERVATION POTENTIAL: 25%

ENERGY FROM	UNIT	PRESENT ANNUAL CONSUMPTION	SAVING POSSIBLE	INVESTMENT REQUIRED OF CREATING EQUIVALENT RESOURCE (RS. CRORES)	TOTAL INVESTMENT REQUIRED (RS. CRORES)
Coal	Mill tones	70	17.5	50	87.5
Oil	Mill tones	4	1.0	60	180
Electricity	Bill/khm	80	52.50 MW	0.90	4725
Total investment for creating to equivalent to energy capacity.					5780
Investments required for implementing energy conservation measures.					3600
Annual Expenditure savings in Industrial Sector by Implementing conservation measures.					1925

TABLE 2B

TRANSPORT SECTOR CONSERVATIONAL POTENTIAL 20%

ENERGY FROM	UNIT	PRESENT ANNUAL CONSUMPTION	SAVING POSSIBLE	INVESTMENT REQUIRED OF CREATING EQUIVALENT RESOURCE (RS. CRORES)	TOTAL INVESTMENT REQUIRED (RS. CRORES)
Oil	Mill tones	12	2.4	180.0	432
Total investment for creating to equivalent to energy capacity.					432
Investments required for implementing energy conservation measures.					890
Annual Expenditure savings in Industrial Sector by implementing conservation measures.					765

TABLE 2C

POTENTIAL ENERGY SAVINGS IN AGRICULTURAL SECTOR

AGRICULTURAL SECTOR: CONSERVATIONAL POTENTIAL: 30%

ENERGY FROM	UNIT	PRESENT ANNUAL CONSUMPTION	SAVING POSSIBLE	INVESTMENT REQUIRED OF CREATING EQUIVALENT RESOURCE (RS. CRORES)	TOTAL INVESTMENT REQUIRED (RS. CRORES)
Oil	Mill tones	1.6 (3.4 Billion units of Electricity equivalent)	0.48 (360 MW capacity electricity)	180.00	86
Electricity		17.8 Bill/ Kwh	1870 MW	0.90	1682
Total investment for creating to equivalent to energy capacity.					1768
Investments required for implementing energy conservation measures.					650
Annual Expenditure savings in Industrial Sector by implementing conservation measures.					410

TABLE 2D

ENERGY CONSERVATION POTENTIAL IN SELECTED UNITS

	Number of units covered	Energy Bill		Saving Potential No of Units		Successful Implementa -tion carried out	Conser- vation yet to start
		Thermal	Electrical	Thermal	Electrical		
Cement	24	121.1	100.7	6.0	10.00	8	2
Chlom Alkali	9	54.1	93.6	----	7.30	5	1
Edible Oil	9	6.5	7.4	1.9	0.75	3	2
Engineering	16	19.5	45.0	6.4	2.25	4	2
Glass	12	19.7	6.15	2.9	0.25	5	1
Jute	10	1.2	15.5	0.3	0.90	3	1
Paper	22	83.5	98.8	12.5	7.30	8	4
Chemical Processing	18	19.2	25.9	4.6	1.80	5	2
Refractory	18	19.2	25.9	4.6	1.80	5	2
Tea	11	6.7	4.1	1.1	0.80	2	5
Textile	34	24.4	54.8	4.9	2.30	20	4
Tyre	5	13.85	14.6	1.8	0.65	4	----
TOTAL	**178**	**377.5**	**476.15**	**43.56**	**34.98**	**70**	**29**

- Figures are in crores of Rupees

Source: Report of follow up of Energy Audit Studies conducted by NPC in 1985.

Table 3

QUANTIFICATION OF SAVING IN INDUSTRIAL SECTOR

Sl. No.	Recommendation	Savings inspected in million tones in Rs. Crores/ of coal equivalent annum per annum	Investment in Rs. Crores	Remarks
	Short term measures			
i.	Implementation of good house keeping measures			House keeping measures includes tuning of combasion equipment proper maintanence of energy consuming equipment condensate recovery insulation etc.
ii.	Training of industrial personal in energy conservation	7.1 616	400	
iii.	Introduction of system of energy audit			
	Medium terms measures			Investment figures indicated have to be borne by industry and government the major portion being meet by the industry.
iv.	Installation of waste heat recovery systems			
v.	Replacement of old inefficiency boilers			
vi.	Introduction of instrumentation and control systems	8.9 772	1200	
vii.	Adoption of better technological innovation like ceramic libers, low excess all burners variable speed drives etc.			
	Long term measures			
viii.	Introduction of cogenelation systems			
ix.	Adoption of newet energy efficient technologies	6.2 5.37	2000	
x.	Introduction of computers for process control on real time basis			
	TOTAL	22.2 1925	3600	

Table 3 (contd)

QUANTIFICATION OF SAVINGS IN TRANSPORT SECTOR

Sl N.o	Recommendation	Savings inspected in million tones in Rs. Crores/ of coal equivalent annum per annum	Investment in Rs. Crores	Remarks
	Short term measures			
i.	Accelerating the national programme on educational campaign for users of road transport	8.0 240	200	
ii.	Inforcing speed limits and abolishing octroi checkpost	3.5 105	30	
iii.	Emulating the concepts of model depots in state transport undertaking	1.0 30	60	
	Medium term measures			
iv.	Adoption of energy efficient technology for new vehicles automobiles and 2/3 wheelers	a) 5.0- HSD 1500 b) 1.5 gasoline 90	300 200	a) for heavy vehicles b) for automobiles and 2/3 wheelers
v.	Formulating and implementing a plan for upgrading the quality of road surfaces	5.0 150	100	The investment has to be incurred on a recurring basis every year

Table 4

ENERGY EFFICIENT TECHNOLOGIES ,DEVICES AND SYSTEMS

A. INDUSTRIAL

Title	Genesis	Application / sector
Fluidised bed boilers	Efficient Combustion of interior high ash content coals and washery rejects.	Industrial boilers ranging from 2 to 50 TPH
Lows excess air burners 0.5%	Improvement in system efficiency	Industrial boilers, furnaces kilns.
Air pre heater	Improvement in thermal efficiency by preheating the combustion air with waste heat available in flu gases.	
i. Metallic recuperator / regenerator heat wheel	Degree of preheat up to 350°	Largest boilers, small furnaces
ii. Metallic recuperartor special steels	Degree of preheat upto 700°	Furnaces rolling and soak pits, glass furnaces ceramic kilns.
iii. Ceramic recuperator / regenerator	Degree of preheat up to 1000°	Integreated steel plants glass tank furnaces
Regulative burners	High flame temperature and improved heat reactions	Industrial furnaces and kilns.
Waste heat boilers	Steam generation with waste heat available in fuel gases or exo-thermic reactions	Sulphuric acid, chemicals, petrol chemicals, fertilizer and steel plants.
Heat pipe	Upgradation of low grade heat	Process industries such as textile chemicals, good processing, commercial building, etc.
Mechanical vapour recompressor system	The low grade steam from heat evaporators, driers, distillation columns is upgrade	Food processing chemical petrochemical industries
Vapour absorption refrigeration system	Trapping low grade waste streams 100-150°c refregeration in an absorpition cycle using lithium bromide or ammonia	Process and engineering industry

Combine cycle based cogeneration plant for industries	High system efficiency 80-90% in the cogeneration mode compared to 35-40% for conventional of thermal and electrical energy from the same source	Natural gas consuming process industries with steam demand above 10TPH
Ceramic fibre	Reduction in heat storage and radiation losses due to low thermal mass	Furnaces, kilins, fired heaters , ovens, heat treatment furnaces.etc.
Automatic power factor controllers	Power factor improvement	Industries
Energy efficient fluorescent lighting system fluorescent lamps, sodium vapour lamps	High lumen per watt.	Building street lights yards
Flat belts	Reduction in transmission losses	Industries
Variable speed drivers frequency drives invertors	High efficient at partial loads	Medium and large industries power plants.
Microprocessor based system a. Combustion control b. Energy management c. Process control	More precise control of the critical parameters.	Boilers, furnace, utilities \ distillation columans process plants, power plants.
Fuel efficient chassis	Special aluminium extended sections to reduce weight & lower aerodynamic drag thereby in better fuel economy.	Passenger transport vehicle
Turbo charge	Development of higher HP by utilizing the waste heat higher power to weight ratio. Smaller engine as compared with naturally aspirated one.	Goods/ passenger transport vehicle
Modified	Modified design for oil to extend fife to 16-111,000KM to coincide with engine oil	Long distance truck and buses.
Radial tyre	Better 5-10% fuel economy due too reduced rolling resistance and longer life 80-100% more than conventional tyres.	Passenger cars, buses and trucks
Battery driven vehicles	Battery operated vehicles substitute petroleum fuels,less environmental pollution	Passenger transport

Wheel range lubrication	Micro processor controlled on board lubrication. It reduces exotic energy besides reduced wear and rear of trucks.	Railways
Locatrol	Remote control system towards the middle or rear of a train redistributing and optimally utilizing draw-bar coupler force. This gives better control besides better fuel efficiency due to reduced rolling resistance.	For heavy haul operation

Table 6

a) Industry

1. Distributed orginal controls for large process industries and utilities.
2. Improved anode / cathode material and cell design for electro –chemical and electro – metallurgical industries.
3. Spared on coating for furnace and kilns.
4. Packaged cogeneration system operating in parallel with grid for application in small and medium industries.
5. Mechanical vapor re-compressors and thermo compressors in process, sugar and confectionery industries.

b) Transport

1. Engines of lower ratings
2. Multipoint fuel injection
3. Battery driven /ING/CNG/ driven busses.
4. 00

c) Agriculture

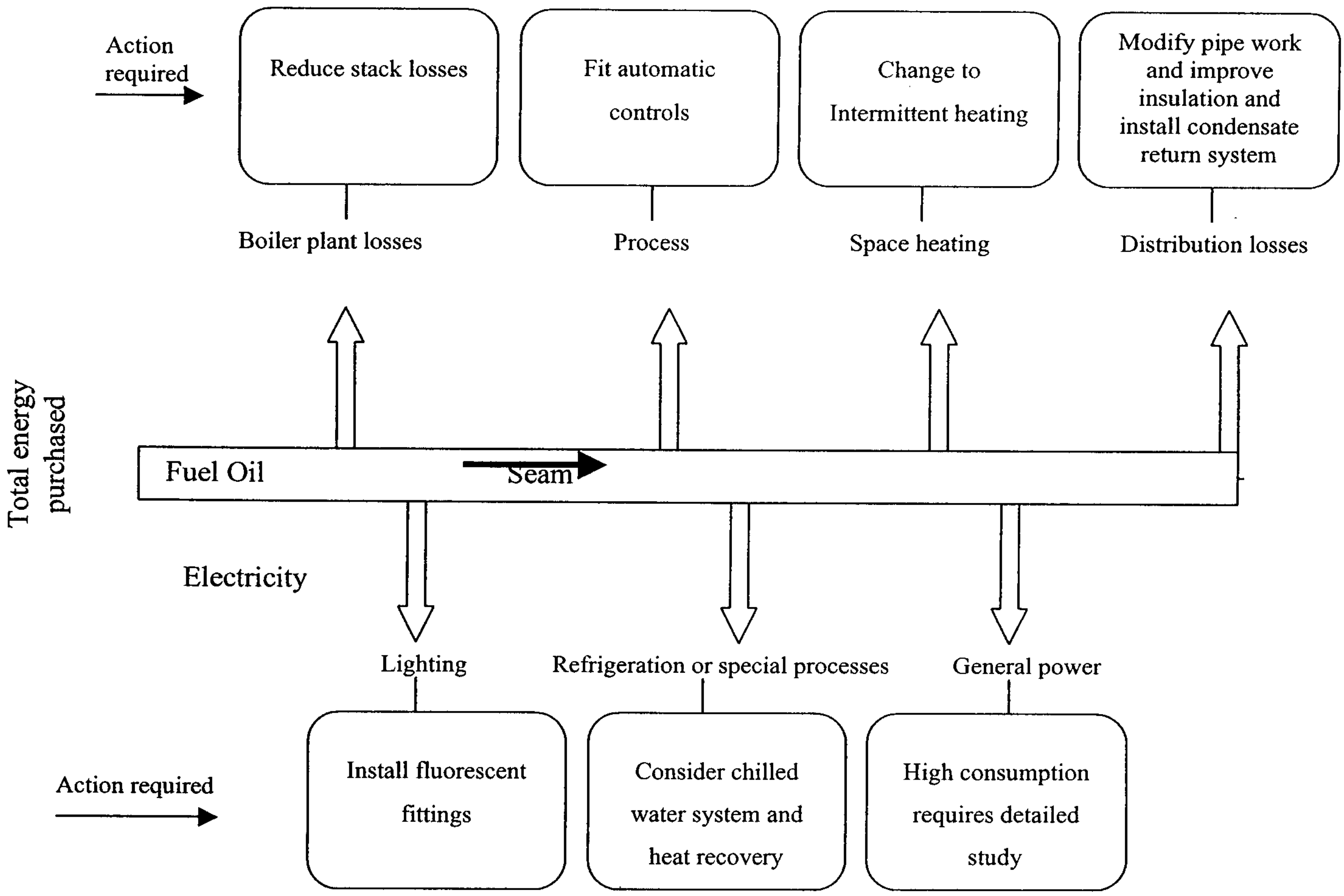
1. Fuel efficient diesel engines
2. Mobioc pump sets
3. Wood gaster for small power stations

d) Domestic

1. Improved chullak s
2. energy – efficient lamps

Scheme	Savings Potential
Cogeneration	Efficiency of 60% to 80% as compared to 30% -33% of centralized power station 2000 MW potential Pay back = 3 – 5 year
Vapor absorption refrigeration from Diesel Engine exhaust	Pay back – 18 month
Plate Heat Exchange	Heat recovery of 80% to 90% as compared to 50% - 60% of ordinary sheet and tube heat exchanger.
Heat pipes	70% heat exchanger effectiveness
Organic ranked	High efficiency of power generation as compared to steam cycle using low grade heat.
Regenerative burners furnace application	45 – 50% fuel saving
Flat belts	5% electricity saving
Ceramic coatings	12% savings
Energy	6% - 75% saving depending on amps.

3. GENERAL OUTLINE OF ENERGY CONSERVATION



3.1 LIGHTING AND ENERGY CONSERVATION

People need light, but they also need to save energy-whether in factory, office, hotel or home. In the past higher levels of illumination meant more and more energy. With the rapid advances made in illuminating engineering, triggered off by the energy crunch, the present situation is that it is possible to increase the illumination levels wherever necessary for higher performance while reducing the energy consumption at the same time.

In creating more energy-effective lighting, emphasis should always be placed on improving or at least maintaining the quantitative and qualitative standards of lighting. The energy-effective lighting philosophy of the eighties is " the right light at the right place and at the right time". This approach places emphasis on good lamp-luminaries system, optimum lighting design and increasing the usage efficiency of the installation as a whole.

3.1.1 LAMP-LUMINAIRE SYSTEM:

Reduction of power consumption of any lighting installation can be achieved by the proper selection of the hardware. It can be done by choosing the most efficient light source suitable for the application, correct luminaire with advanced optical system and suitable control gear with low losses.

Present day electric lamps have efficacies ranging from 9 lumens/watt of the ordinary incandescent lamps to 125 lumens/watt of the low pressure sodium vapour lamp.(refer table 1). In case of incandescent lamp, the development trend is either to improve lumens per watt ratio or to adopt direct light technique. In halogen incandescent lamps the former is achieved and in compatux or superlux lamps, the latter is made use of. Still the efficiency of incandescent lighting system is poor. For better results the present day incandescent lamps can be replaced by the new wattage low pressure gas discharge lamps- the PL and SL lamps. The PL lamps have comparable colour rendering qualities and consume only 22% energy when compared with an equivalemt incandescent lamp. A PL 9W or a SL 13W lamp can replace a 60W incandescent lamp.

Similarly in fluorescent tube range the slim 26mm diameter 'TL' D lamps can replace the 38mm diameter conventional TL lamps directly resulting in 8% saving in system wattage. A 'TK' D 36W can replace a 'TL' 40W without any change in light output. Development of colour 80 series and 90 series by using highly efficient fluorescent powders has resulted in efficacies exceeding 90 lumens/watt in fluorescent lamps.

Where colour rendering is not critical like roads, outdoor utility areas or in most of the industries, high pressure sodium vapour lighting can be advantageously used to meet the dual requirement of saving energy and adequate illumination levels. Jlow pressure sodium vapour lamps give even better results. But they can be used only where colour rendering is most unimportant like lighting of highways, security lighting, rural roads etc. when we need both higher colour rendering and higher efficacy, metal-halide lamps provide the alternative.

Choosing the proper luminaire is as important as choosing the right lamp. Luminaires help in maximum usage of light if they have a superior optical system. For example, widespread luminaires for fluorescent lamps having batwing light distribution can reduce the number of rows of luminaires by one-third. Air handling luminaires facilitate the lamp to operate under optimum temperature conditions. As the return air passes through the openings in the luminaire, the air temperature around the lamp is reduced. This also reduces the sensible heat load in the room resulting in lesser air conditioning load. The clutter on the ceiling is also reduced. Computer designed facetted mirror optic luminaires can be used for road lighting and flood lighting applications for excellent optical control.

Gas-discharge lamps need control gear for their operation. Reducing the inherent ballast losses also can result in saving in energy. For fluorescent lamps recently developed low watt loss ballasts save considerable energy. For high pressure gas-discharge lamps the development of orthocyclic ballasts enabled substantial savings in valuable material and size of the luminaire. Inductive ballasts with their inherent copper and iron losses can be efficient only to a certain extent. With the help of electronic ballasts the losses can be greatly minimised. We can definitely say that the future belongs to electronic ballasts. Also, with electronic ballasts dimming is possible more easily.

3.1.2 OPTIMUM LIGHTING DESIGN:

It is necessary to use the lumens generated effectively for best results in terms of both light and energy. The designer can reduce the energy consumption by the proper choice and arrangement of lamps and luminaires. One way of evaluating any lighting design is to find out its Energy Effective Lighting Ratio as given below:

$$\text{Energy Effective Lighting Ration (EELR)} = \frac{\text{Target w/m}^2\text{/100 lux}}{\text{Achieved w/m}^2\text{/100 lux}}$$

if the ratio is closer to one, then the designer did an energy effective job. But it does not tell us whether he has created the right luminious environment which is not to be neglected.

The software of the designer should give best lighting results for minimum watts. This can be achieved by the following means :

- Choosing the proper light sources suited to the system such as rendering, higher efficiency etc.

- Proper selection of luminaires to use the mamp output efficiently.

- Proper arrangement of the luminaires considering the standards of lighting and structural limitations.

- Introducing control strategies based on variations in task (nature and location), variations in occupancy (location and time) and variations in the available daylight.

- Combining local lighting with general lighting for intricate jobs requiring very high level of illumination. The lighting is to be provided for creating the right luminious environment conductive to the work carried out.

3.1.3 USAGE EFFICIENCY :

It is not necessary to have 100% artificial light over the entire area for all the time. Demand adaptable lighting installations (DALI) having different forms and degrees of light control can provide significant saving in energy and cost by optimising the usage of lighting. A simple example can be found in road lighting.

At late hours when traffic dies down, it may do no harm by reducing the lighting level to 50% or less. It should be emphasized here that randomly switching off the light will do more harm than good. It may result in poor uniformity with dark patches, making it uncomfortable for the road user. Switching, if resorted to, is to be done in a selective way so that the quality does not suffer. Dimming achieves this more easily. So it is better to have dimming facility than switching off in such conditions. Wherever possible it is preferable to have more light points for a flexible system. Such a flexible system reduces energy consumption to the least.

The use of natural daylight can be made in the window zone. The row of luminaires near the windows can be switched off or dimmed. When air-conditioning system is used, an analysis of heat load due to daylight and reduction in energy for lighting is to be done before going in for natural daylight. The lighting can be completely or partially switched off when not in use either manually or by time controlled switches.

Last but not the least aspect is the maintenance of lighting equipment. Without regular maintenance, the lighting level falls down due to soiling. At the same time, there is no reduction in the energy bill. If the installation is designed for certain maintenance programme then, it should be adhered to for realising adequate lighting level at all times. Lamps need not be allowed to burn until they fuse. Every lamp has an economic life because of lumen depreciation due to ageing. It will pay if lamps are replaced at the end of their economic life. This will also facilitate group replacement, reducing the time and cost of replacing individual lamps when they burn out.

The above principles can be summarised to six basic rules for obtaining more productive and pleasant environment, with saving in energy and cost as well.

Rule 1: Use the most efficient light source available.

Rule 2: Use the lamp light output efficiently.

Rule 3: Maintain lighting equipment in good order.

Rule 4: Use well designed energy effective lighting schemes.

Rule 5: Control the switching operation and usage of the lighting Installation.

Rule 6: Consider the effect of surrounding décor.

The task of designing new energy/cost effective lighting installation or the identification of energy/cost saving opportunities in existing lighting installations is frequently regarded as the responsibility of the engineering function. In practice good energy management requires the assistance and co-operation of many other management and operational disciplines with the organisation. The best overall result can only be achieved by the co-ordination of Engineering, Finance, Purchase, Administration and Operational Staff at all levels.

SURVEY OF CHARACTERISTICS OF REPRESENTATIVES TYPES OF LAMPS

LAMP	WATTAGE	LUMINUOUS EFFICIENCY (1m/w)		COLOUR RENDERING INDEX	AVERAGE LIFE IN HOURS
		LAMP	LAMP BALLAST		
Tungsten Incandescent (GLS)	25 to 1000	9 to 13	_	100	1000
Tungsten Halogen	1000	22	_	100	2000
Fluorescent 1.Cool day light	1.TL20/40/65 2.TLD18/36 /58	49 to 62 54 to 69	32 to 50 38 to 54	77	5000
2.White	1.TL20/40 2.TLD 18/36	58 to 69 64 to 77	38 to 54 41 to 58	65	5000
Blended lamp	160/250	18 to 21	_	50	5000
High pressure Mercury Vapour	80 to 1000	44 to 57	48 to 54	45	5000
High pressure sodium vapour	150/250/400	90 to 118	79 to 107	25	more than 12000
Low pressure Sodium Vapour	35	125	91	_	more than 12000
PL	9	67	46	85	5000
Metal halide *	250 to 2000	68 to 95	63 to 90	70	For 250 / 400 w more than 8000 For 1000/ 2000 above 8000

* Not available in India

3.2 ENERGY SAVINGS IN REFRIGERATION

Too few users of industrial and commercial refrigeration plant realise the potential for saving on their energy costs. The question of energy saving in this field has been neglected by the plant users. The first step is to become aware of the problem. Once this is done and the potential scope for energy savings is understood further steps can be easily identified as outlined below:

Access what the cooling is being used for. In many cases refrigeration is not really needed , or at temperature lower than are necessary.

Analyse the performance and efficiency of existing plant –this will show up all forms of energy wastage including design faults , and operational or maintenance problems. Such analysis should be repeated periodically.

Take energy consumption into account when buying new plant. The careful selection of a compressor , for e.g. can improve running costs by as much as 25%. Energy savings are always easiest to achieve at the design stage.

After a new plant has been installed , have the performance assessed independently. It is amazing how many faults fail to be discovered during commissioning.

The following e.g.s highlight the problems that exist .The cases outlined below-from which the names of the client companies and the manufacturers of the plant have been deliberately excluded – all are true.

3.2.1 IMPROPER USE

When assessing a plant it is essential to identify where the refrigeration capacity is being used . During a recent study of a low – temperature cold store it was found that the 'genuine' cooling requirement (i.e. to account for losses through the building fabric) was only 28% of the trial.

The remainder was mainly fan power to circulate the air, lighting load , and warm air infiltration . Each of these have been substantially reduced , thus lowering the overall cooling requirements.

3.2.2 WRONG INSTALLATION:

For several years a brewery had been having problems keeping beer conditioning room cold enough in summer . Plant analysis showed very little air flow over the cooling coils, and a subsequent investigation showed that the fans had been installed upside down – with ' outlet ' guide vanes.

After modification , the cooling rate of the coils increased by 70% , saving energy and , more importantly , improving product quality. This fault should , of course , have been recognised during initial commissioning tests , but these are rarely carried out to a sufficient level , if at all.

3.2.3 OIL FOULING:

One of the commonest causes of energy loss in ammonia refrigeration plants is oil-fouling of the evaporators. The presence of oil lowers the evaporating temperature of a refrigeration plant , thus increasing the energy consumption and reducing the cooling capacity .Such energy loss can be upto 30%.

A probable reason for this fault going unnoticed is that some operators assume that a compressor user oil in same way as a car engine by running it.

However , this is not the case –any topping –up of oil in the compressor must be accompanied by a build up of oil elsewhere in the refrigeration circuit . The remedy is to purge the oil every two or there months ,which is a quick and easy operation .

3.2.4 PLANT SELECTION:

The efficiency of apparently similar refrigeration compressors can vary considerably. When comparing the performance oftwo tenders for a new plant, the compressor efficiency were discovered to be 52% and 78%.

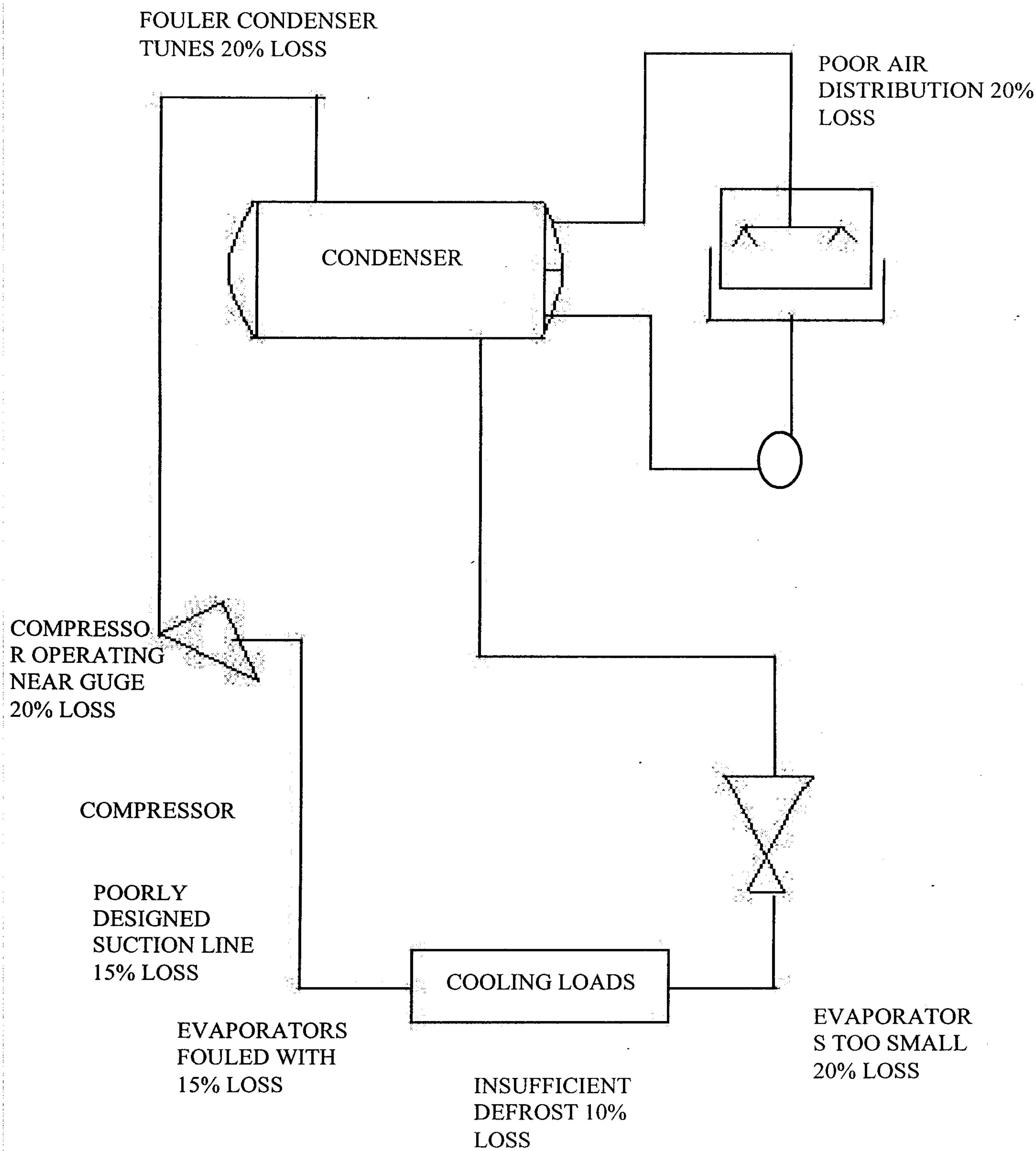
The resulting running costs being directly proportional to the compressor efficiencies , the difference is significant . The careful selection of more efficient unit worked out 30% cheaper than the other.

3.2.5 POOR CONTROLS:

It is not unusual to find perfectly good plant operating in-efficiently due to a poor control system . In one particular air conditioning system ,within a large

Hospital complex , 12 chillers of 1 MW capacity were on load .On investigation , it was discovered that each was operating at about 25% of full load.

The efficiency of a compressor running at only 25% load is far below its value at 100% load. The control system should have shut down 9 machines and run the remaining 3 at their most efficient level. Thus refrigeration plant operations offer important scope for saving electricity costs.



CAUSES OF ENERGY LOSSES IN REFRIGERATION SYSTEM

3.3 THERMAL INSULATION

3.3.1 INSULATION PRACTICE

Whilst generating and transmitting ,steam is essential to ensure that heat is not lost and hence it is neccessary to insulate the steam generator,connected piping and the various vessels.The design of an effective insulation is a balancing trick.It neccessitates a close study of the various parameters with a view to achieving end results which are (1)technically feasible and (ii)economically justifiable.

What is Thermal Insulation?

Broadly,Thermal Insulation may be defined as the process of restricting undesirable heat transfer to or from a system to the environment and encourage the heat produced to a full use as possible.

85% Magnesia:

It is a mixture of 85% by weight of pure hydrated carbonate of magnesia and 15% of stranded asbestors fibre,moulded and pressed into shapes,the latter being used a hindering agent for the former but both having a low rate of conductivity.it should not be used above 650 deg F.At high temperature, magnesia is decomposed into carbondioxide and magnesium oxide powder.this disadvantage can be overcome by interposing a thin layer of special cement between magnesia and hot surface.Magnesia lagging is obtained in the form of slabs which are laid along a pipe and secured temporarily with strands of wire.

A hard setting compound is then applied to the outside in order to secure the slabs permanently and also to fill the gaps

Between adjacent slabs.This 85% magnesia is going out of use.

Calcium and Aluminium Silicate moulded into pipe sections and slabs using asbestos fibre as a binder has a high resistance to the effects of temperature upto 1250 deg F,also a relatively low K.This is used as lining in hot face situtation.The maximum in service temperature is 1400 deg F.When calcium silicate is employed as backing for orefactory lining it can withstand safely constant exposure to 1750 deg F.The material's value as a furnace lining in a combination of refractory and insulating properties with light weight (density 15ib/cft).Its use also considerably speeds up the lining and relining operations, presenting craftsmen with easily cut sizeable slabs in place of numerous bricks.

For applications where it is impracticable to employ a performed insulant plastic versions of calcium silicate are suitable.It is a useful insulant on irregular vessel ,equipment shapes ,complicated or hard to wrap pipes and on repairs to existing lagging.Both solid and plastic forms have good resistance to vibration.

VERNICULATE:

This is an insulating aggregate made by exposing to heat hydrated laminar flakes of various AL/FE/MG silicates. In their unexploited state they look like mica. Structurally the blown up granules are very similar to cork and the characteristics are similar: but , vermiculate is inorganic and able to withstand much higher operating temperature upto 1850 deg F. Furnace lining involves a combination of vermiculites with various binders, notably high aluminium content or silicated (for monolithic application)and fire clay to make bricks. Much lower down the temperature scale vermiculite has many applications in building as loose fill insulation of cavity walls, and chimneys water heaters, tank roofs and floors.

DIATOMACEOUS EARTH:

This is an aggregate for insulating concrete(Alumina content)for work up to 1650 deg F. Its chief value lies in the combination of thermal efficiency and physical strength in exhibits when made into bricks. These bricks should be used behind refractory linings purely as insulation, purely Diatomaceous earth, also known as Kieselguhr is obtained as a very light rock formed from the skeletons of minute organizations. The bricks may be cut from the raw material, rock and used directly, but when used, the water they contain, is driven off at red heat resulting in considerable shrinkage. The bricks may also be manufactured from the earth by calcinations.

MINERAL FIBRES:

GLASS ROCK AND SLAG:

In the molten state these are spun into very fine strands(down to 2mm in dia).In themselves they possess no insulating capability but woven or pressed together into a mess, they trap air which does.

The wool is made up into blankets or mattresses about 3'0"long. The width is such that it can be rapped once around the pipe. When the required thickness of lagging is more than 2 " ,it is advisable to obtain this thickness by installing two layers of mattresses, one on the top of the other.The material has the density of 1b/cft.Special inorganic binders and organic additives in mineral fibre board and salt allow them to withstand higher temperature of 1800 deg F.

Glass fibres for thermal insulation are produced from a molten mixture of sand , lime and soda. At temperature below about 600 deg F,glass wool has a greater thermal resistance than slag wool or magnesia. It is more expensive and cannot be used for temperatures higher than 950 deg F.

PROCESSED GILSONITE:

Is a granulated naturally occurring hydrogencarbon of high resin content. It is a loose bulk insulation for underground piping at maximum temperature of 460 deg F.

Table 4 gives the properties of some of the common insulating materials.

Refractories take over the insulation job at higher temperature:

Combustion and chemical or metallurgical process occur at temperatures upwards of 1800deg F.Insulation is necessary to protect structure and workers to conserve heat. This insulation often faces for more conditions than does low or medium temperature insulation in piping or vessels (i.e.)abrasion and erosion by molten metal or slag , direct flame impingement , corrosion atmosphere , severe thermal shock , only the special class of insulation known as refraction known as refractories can withstand these conditions.

A refractory is essentially a ceramic material in a form designed to result temperatures of 1800-3200deg F and other severe requirements as needed.Types of materials include fire clay , high alumina and silica .Practically all refractory lining materials have high thermal conductivity and unless they are backed with an efficient heat insulating material , heat flows rapidly to atmosphere instead of being retained in the hot face.

In form , refractories can serve as brick , as castable material , as loose aggregate and fill , as fibre felts or blankets.The brick form is more common in heat treating furnaces , kilns , oven ducts , flues , high temperature reactor vessels , boilers and incinerators.

Castable refractories are chiefly a mixtureof alumina or alumina/silica aggregates with hydraulic setting cement .Clean water added to the mix gives a product that cannot be throwelled forcefully into place or applied at high velocity by a pneumatic gun.

Ceramic fibre board , made of alumina/silica fibres with binder is available for lining vessels upto 2250 deg F.The material has some abrasion resistance .Thickness range from to 2".Heat resistant studs hold the board pieces to the lower temperature block insulation which backs up the board. Resistance to temperature of 2100 deg F is made possible by a patented method of attaching ceramic fibres and on to an insulating backing of a vermiculite block further backed by mineral fiber. The result is a furnace wall of low thermal capacity and conductivity less than 120 mm thickness which has the insulation and refractory capability of 230 mm thickness insulation brick construction.

Until requirements became more exacting, redbrick was widely used to provide insulating; to protect the refractory lining and to carry the main wall loading. The modern tendency is to employ more efficient material for the insulating duty and to carry the super structure on brick walls or steel work. The advantage of insulating material is that being more efficient than red brick, it affords more economical service with less heat storage in the walls.

When insulation is placed behind the refractory lining of a high temperature furnace , an interfacial temperature may rise above the value permissible for normal insulating materials.(The best procedure is to use insulating refractories).Two methods of insulation are preferred. When the furnace is operating continuously or where the conditions of temperature and atmosphere are very severe , insulating refractories are used for backing the refractory linings. In other insulations where cleaner conditions or a lower temperature permit and particularly in short cycle intermittent furnace and kilns.

INSULATING REFRACTORIES:

Materials of this type are highly porous and refractory and have fair strength and spalling resistance.They are in general to be used upto a temperature of 2400 deg F.Some recently developed refractories can be used at a hot face temperature of 2750 degF.

The insulating refractory increases the uniformity of temperature in a furnace for three reasons

(i) The heat radiation is high because of the high surface temperature

(ii) The temperature drop along the path taken by the gases is proportional to the heat losses from the furnace walls. By reducing the heat loss , the temperature drop is reduced.

(iii) The flow of heat parallel to wall face and towards doors and other openings is reduced.

An important limitation as insulation refractories is their poor resistance to slags. The external structure being highly porous is readily penetrated and dissolved by fluid slag and although coatings have been tried , they have been only partly successful.

A second limitation is rather low resistant to abrasion which prevents these bricks from being used as a working hearth. For the same reason they cannot be recommended for positions , where they will be scoured by dust gases at high velocity , unless they are coated with a denser material. The resistance to heavy mechanical vibration is not so high as with firebrick and in forging furnaces adjacent to heavy hammers , for example ,it is advisable to use heavier and more rugged constructional materials.

INSULATING BRICKS:

Hot face insulating bricks are higher than normal refractories weighing perhaps only one third to one half as much. Moreover the heat penetration into the brick is less and the use of these bricks result in much less heat storage in the furnace walls. The insulating bricks are also made from diatomaceous earth .The maximum temperature is about 1600 deg F. Valve is 0.6 to 1 btu/hr.sq.ft deg F./in.

Insulating brick function as such because of their high degree of porosity which necessarily involves mechanical weakness.

They are quite unsuitable for exposure to temperature in excess of their working temperature in to slag would choke the pores.

SELECTION OF AN INSULANT:

The following main factors are to be taken care of in the selection of an insulant for a particular system:

(i) The operating temperature of the system.

(ii) Thermal conductivity of the insulant.

(iii) Capability of the insulant in getting applied to hot surfaces readily and cheaply.

(iv) Resistance to heat , weather and adverse atmospheric conditions.

(v) Ability to withstand vibration , noise and accidental mechanical damage.

(vi) Resistance to chemicals.

(vii) Resistance to fire.

(viii) No shrinkage or cracking during use.

(ix) Jacketing the insulation.

(x) Total cost including maintenance costs.

Final decisions you make must be governed by a host of factors. Only some are covered here. Your ultimate choice of a system will be an engineering decision that brings all "factors in" true perspective. And one of these factors is insulation thickness as discussed below.

The most economic thickness calculated on the basis of:

- Cost of useful heat (Y)which is given by the cost of fuel divided by the product of boiler efficiency and calorific value of fuel.

- Return on capital(m).
- Plant life (z).
- Years of repayment=1/(m+I/z)
- Evaluation period (H)=years of repayment X hours of operation /year.
- Cost of heat loss over the evaluation period (H) is given by Yhq , q being the calculated heat loss through the insulation.
- Cost of heat loss prior to insulation over the evaluation period is Yhqb (qb being the heat loss prior to insulation).

Using the above data, the economic thickness is determined by first computing the heat loss per year. Then figure out the installed insulation cost per year. Latter figure equals cost of 100 linear ft. or 100 sq.ft.of insulation divided by amortization period .Finally add the cost of heat loss to the insulation cost . As this summation is plotted for various values of insulation thickness , the low point on the curve indicated economic thickness.

Economic thickness pays for itself over a given period plus earning a return on its original. From the very definition it is clear that any changes occurring in the prices of fuel or in the insulation costs , will tend to shift the economic thickness to another value. Hence what was economical in 1970 may not be economical now . This is particularly because of the drastic increase in the fuel prices in the recent past .Based on the economical structure , one has to review the entire insulation system and see if any additional insulation is necessary so to achieve optimum fuel economy .

CALCULATION OF HEAT LOSS AND ECONOMICS OF INSULATION:

CALCULATION OF HEAT LOSS:

Heat loss from insulated flat surface:

q=(to-ta)/{(L/K)-(I/f)} --------------------(i)

ts=q/f +ta --------------------(ii)

Heat loss from insulated cylindrical surfaces:

Q= (to-ta)/{d log e +d/f.d1} --------------(iii)

Ts=(q/f)x (d/d1)+ts -------------------(iv)

Thermal efficiency ={(qb-q)/qb} x 100 ------- (v)

In the above formulae,

Q = heat loss through the insulation per unit area of hot surface in kcal/hr .sqm

Qb = heat loss prior to insulation kcal/hr.sqm

Tc=temperature of hot surface in deg C.

Ta=average atmospheric temperature in deg C.

L =thickness of insulation in metres.

K=thermal conductivity at mean temperature in kcal/hr.cum

D=outer diameter of bare pipe in metres.

D1=outer diameter over the insulation in metres.

Ts=surface temperature over the insulation in deg C.

Tm=mean temperature (ta – ts)/2 in deg C .

F= surface co-efficient under still air conditions in kcal/(hr.sqm) deg C.

(i)For bright surface e.g .polished aluminium. f=4.88

(ii)For planished or galvanized steel , aluminium paint and comparable surface. f =6.84

(iii)All dull surfaces f=8.80

SELECTION OF A SUITABLE FINISH:

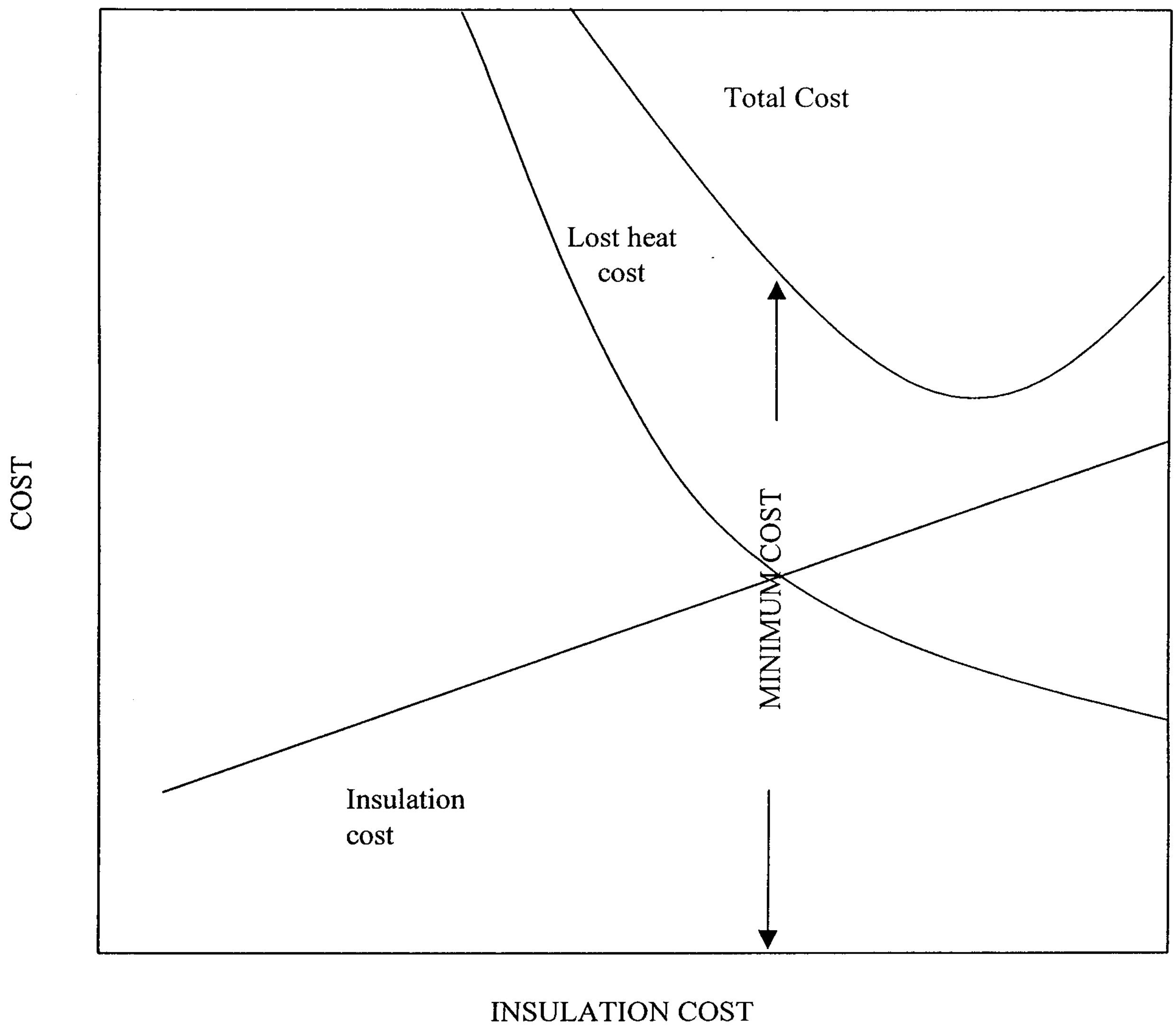
The selection of a suitable finish is dependent on various factors such as situation of the equipment to be insulated , the mechanical load appearance desired , etc.

Sheet metal (aluminium .g.i. or m.s.) has now been generally accepted as a standard finish for insulation of outdoor pipes and vessels.Where first cost is an important considerations , a layer of hard setting non-conducting cement may be provided with a layer of water proofing felt , sealant with bitumen and secured with wire netting , to provide a water proof protection for the insulation.

For indoor pipes and vessels, a layer of hard setting finish with cotton or jute canvas is generally used .

For ground –level piping ,the insulation should be designed to withstand foot traffic or other mechanical damage .This is achieved by using a combination of chain link mesh and ½" layer of asbestos cement compositions ; water proofing may then be carried out with roofing felt as explained above.

ECONOMIC THICKNESS OF INSULATION
FIGURE - 3



3.3.2 HEAT PIPE

Heat pipe is a recent development that shows great promise as a heat recovery devise mainly because it has no moving parts.

As shown in Appendix –4 , the heat pipe consists of a hollow tube lined inside with moist fabric wick .One end of the tube is put in the path of either direct heat source or hot waste gases . The heat from the hot waste gases evaporates water from wick lining and the vapour travels to other end of the tube , along the entire length which is well insulated .The other end of the heat tube is located in the path of cold fluild (say water).Heat is absorbed from vapour by this water and the vapour condenses on the wick and condensed water , by capillary force travels to the front and (hot gas side) of the tube. Thus heat from hot gases travels to cooler fluild (water).The conventional method of transferring heat from hot gases to the surrounding water , would normally give overall heat transfer co-efficient of 1000K.cal /sqm/hr.degC. The figure also indicates the vapour pressure and liquid pressure gradient indicating the pumping pressure, which pumps the heat from the hot gases to the cooler fluid . No gravity is needed. It will be seen that the heat pipe is 25 times more efficient heat tranmission instrument than conventional ones.

Heat pipe can be used in infinite ways to transfer heat . Heat pipe can replace many shell and tube heat exchangers . Air preheating could be done by heat pipe connected to hot exhaust gas in cars . Now-a –days , when fuel for power generation is a challenging problem , we can think of heat pipe application for the total energy concept .

The possible application of heat pipe in extracting heat from chimney gases by concentric heat pipe (for feed water heating) is shown in figure 1 , appendix –5.

Selection of the working fluid depends on the operating range of heat pipe ,for eg ammonia ,freon ,methonal are used in low temperature range etc..

4. ENERGY AUDIT

A lot of publicity has already been given to encourage energy conservation but not much is know about the specific ways and means to achieve the same. Energy Audit deals with this aspect at length.

Energy Audit is the key to a systematic approach for decision-making in the area of energy management. It attempts to balance the total energy inputs with its use; and serves to identify all the energy streams in a facility. It quantifies energy usage according to its discrete function.

Industrial Energy audit is an effective tool in defining and pursuing comprehensive energy management programmes. In this field also, the basic functions of management like planning, decision-making, organizing and controlling, apply equally as in any other management subject. These functions can be effectively performed, based on reliable information, which can be made available to the top management by applying Energy Audit techniques.

4.1 THE NEED

With the advent of energy crisis and exponential hikes in the cost of different forms of energy. Energy Audit is manifesting its due importance in various sectors. Energy Audit will help to understand more about the ways energy and fuel are used in any industry, and help in identifying the areas where waste can occur and where scope for improvement exists.

The Energy Audit would give a positive orientation to the energy cost reduction, preventive maintenance and quality control programmes which are vital for production and utility activities. Such and audit programme will help to keep alive variations which occur in the energy costs, availability and reliability of supply of energy, decide on appropriate energy mix, identify energy conservation technologies, retrofits for energy conservation equipment and like.

In general, Energy Audit is the translation of conservation ideas into realities, by blending technically feasible solutions with economic and other organizational considerations within a specified time frame. This technique will be more beneficial than piece-meal injection of short-term measures, without adopting a scientifically evolved strategy including gearing up of organizational structure and other infrastructural requirements.

4.2 TYPE

Energy Audit attempts to balance total input of energy with its use. The type of Energy Audit to be performed depends on:

- The function and type of industry.
- The depth to which final audit is needed, and
- The potential and magnitude of cost reduction desired.

The primary objective of Energy Audit is to determine ways to reduce energy consumption per unit of product output or to lower operating costs. The extent and type of Energy Audit should result in gains commensurate with the efforts.

There can be two types of Energy Audit –

i) Preliminary Audit

ii) Detailed Audit

Preliminary Audit is performed in a limited span of time. It focuses on major energy supplies and demands, accounting for at least 70 percent of total energy requirements. The Detailed Audit goes beyond quantitative estimates to costs and savings. It includes engineering recommendations and well-defined projects with priorities. It accounts for approximately 95 percent of energy utilized in the plant. A long-range energy plan can be drawn up on the basis of data generated and analyzed.

The Preliminary Audit can be an effective follow up for measuring the progress of the Plant Energy Management Programme (if any) that has been drawn up earlier. It may also form the basis for deciding the modalities of Detailed Audit.

The two types of audit are compared and shown in Table –

TABLE - 1

	Preliminary Audit	**Detailed Audit**
Objective	Set priorities for optimizing energy consumption	a) Quantify energy consumption/utilization. b) Evolve detailed engineering or options to reduce energy costs/consumption
Scope	Highlight energy costs and wastages in major equipment/process	Formulate a detailed plan on the basis of quantitative and control evaluation.
Duration	2 to 10 days	1 week to 10 weeks
Audit Frequency	Difficult to decide	Maybe 2 to 3 years in normal cases *
Preparation	a) No Pre-Audit visit required. b) Detailed questionnaire to be compiled before the audit.	One/Two pre-audit visits required. In addition to points for preliminary audit, the following points have to be taken care of: i) Advance notice to departmental heads. ii) Arranging for office and secretarial support. iii) Advance tentative schedule. iv) Audit Kit to be meticulously planned/arranged.
Due date	Within two weeks of completion of field work	Within 3 months of completion of fieldwork.

* However, for energy intensive industries it may be on an annual basis.

4.3 METHODOLOGY

There is no set methodology, which can be readily tailor-adapted for conducting Energy Audit in all plants. What works in one plant may fail in another. It depends on the management's philosophy, history and culture of organization, type of plant and machinery, financial conditions of the company and technological and process intricacies. In essence, Energy Audit directs and controls the energy management programme. A general questionnaire is, however given in Appendix –I which will help in identifying areas while carrying out an Energy Audit study. An energy management programme, which can be steered through a well-conceived Energy Audit system, is highlighted hereafter.

4.4 PRE-REQUISITES

Before starting any energy management programme, the top management should assign the responsibilities of energy accounting, auditing and analysis to an internal and /or an external group. The executives from various departments like production, utilities, maintenance and finance should be brought together in order to review the findings at periodic intervals.

Necessary financial, organizational and infrastructural support for implementing and reviewing energy conservation measures should be provided to this group.

The involvement of the representatives from different departments/labour unions is necessary to make the energy conservation measures effective.

4.5 SCOPE

The needs and objectives of the Energy Audit are to be identified. The functions areas to be studies are selected based on overall energy consumption figures of the organization.

The scope of an Energy Audit varies according to the facilities being audited. At one extreme is a light manufacturing operation where lighting, ventilation and air-conditioning are the major energy uses. While at the other end, there are integrated process units like refineries and petrochemical plants, where cascading of energy and complex energy balances are involved. The different scopes of Energy Audit are listed in Table 2.

- Analyze present consumption and past trends in details.
- Review lighting requirements
- Consider sub metering
- Compare standard consumption to actual
- Produce and energy balance diagram for the firm.
- Review existing energy recording systems.
- Compare consumption with other locations, other firms, previous period and budget.

- Check records against invoices.
- Compare meter reading against records.
- Review records of maintenance engineer.
- Check capacities and efficiencies of equipments.
- Check working of controls.
- Examine need for automatic controls.
- Determine adequacy of maintenance.
- Review fuel storage and handling.
- Examine need for improved instrumentation.
- Consider training energy management staff.
- Review new projects with respect to energy use.
- Introduce life cycle costing.
- Consider changing the management information system to include energy parameters.
- Develop energy use indices to compare performance/productivity.
- Introduce energy use monitoring procedures.
- Check frequency of energy reporting systems.
- Examine and monitor new energy saving techniques.
- Examine need for energy saving incentives.
- Consider publicity campaigns and incentives.

4.6 DATA COLLECTION

Basic data concerning the overall energy consumption, its cost and production figure for a maximum period have to be collected. These figures, when compared, given a trend of energy consumption and its cost per unit production over the years. Energy consumption in different forms should be expressed in a common unit. (Kcal/Kwh/GJ) to facilities easy comparison.

4.7 ENERGY CONSERVATION PROPOSALS

Energy audits result in energy conservation proposals or projects, initially proposals with minimum investments are identified such as :

- Improvement in the standard maintenance of thermal insulation, instrumentation, combustion equipment., etc.
- Carrying out of plant efficiency trails
- Excess air control
- Stopping leakages
- Re-allocation of electric motor.

4.8 CONTROL

A reporting system of energy consumption should be advised and incorporated in the Management information systems. This will help in evaluating and reviewing the different energy conservation programmes implemented.

This necessarily calls for proper metering system at key points. The reliability of the data is most important. It, otherwise, would jeopardize the whole exercise. The data thus generated will give a clear picture of the status of different energy conservation proposals/projects against the targeted value. It leaves enough room to re-organise the programmes accordingly, if the result are found far short of the target.

4.9 CONCLUSION

Energy audit is an effective tool in defining and pursuing a comprehensive energy management programme. A careful audit of any type will give the unit a plan with which it can effectively manage the plant energy system at minimum energy costs. This approach would be useful for industries in combating benefits like improved production, better quality, high profits, lower emission etc. The approach would broadly be the same in any type of industry and service . The basic formats may have to be suitable modified for different types of industries.

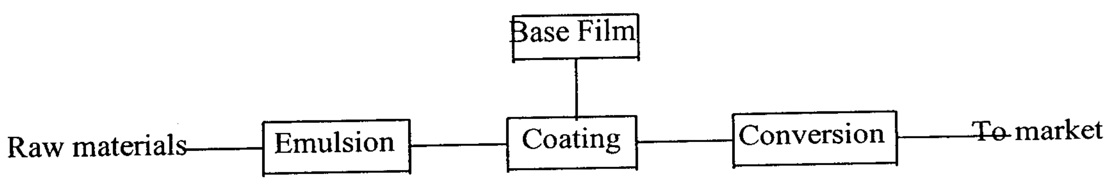
5. OVER VIEW OF THE COMPANY

PXP is a polyester X-ray plant designed to produce the following types of products:

(a) Medical X-rays	-180 micro thickness
(b) Graphic arts	-100 micro thickness
(c) Industrial X-ray	-180 micro thickness
(d) MMR-sheet form	-180 micro thickness
- Roll form	-100 micro thickness
(e) MIF	-180 micro thickness
(f) ADP	-100 micro thickness

The process involved in producing all the above said products are the same with some changes made in the emulsion department(Chemical preparation).

The general outline of the process is shown below :



5.1 EMULSION:

In emulsion department ,

Raw materials (ie)chemicals like Silver nitrate , NH_3, CP16 , etc are stored in fourth floor.

Solution preparation is done in the third floor.

Solutions are mixed and prepared into one make in the second floor. This floor is called as MAKE ROOM.

(MAKE – solutions that are ready for coating).

Here water jacketed kettles are used to maintain the solutions at particular temperature, otherwise those solutions will lose its photographic characteristics.

Then in the first floor , the solutions from make room is allowed for digestion and then they are stored in cold room at 5 deg centigrade temperature.

When the solutions are required to coating department , then they are remelted from the cold room and supplied to coating department in the ground floor.

UTILITIES in emulsion:

Hot water 90deg C from boiler

Çold water 2deg C from heat exchanger.

Chilled brine – 2deg C to maintain cold room at 2 deg C.

Distilled water for solution preparation.

Process water for cleaning purpose.

5.2 COATING:

Coating department gets Emulsion and Overcoat from Emulsion department. Here the base film is mounted on the spindle and by rotating the spindle , the base film is made to move through the point of coating and then inside a driver where different temperature zones are maintained indoor to dry the emulsion coated on the base film.

Two layers are coated at the point of coating . First emulsion is coated on the surface of the base film above which a layer of overcoat is coated to protect the coated emulsion.

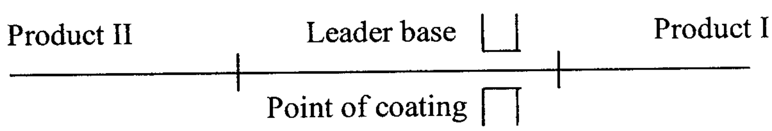
Then the coated base film is wound on the other end and taken to the conversion department for converting into the required sizes.

The different temperature zones maintained in the driver are :

	DP	DB
(a) Chill zone	0 to –5	10 +/- 2
(b) Zone –I	+2	34+/- 2
(C) Zone – II	2 +/- 2	36+/- 3
(d) Zone – III	12+/- 2	28+/- 2
(e) Zone – IV	14+/- 2	28+/- 2
(f) Conditioning zone	17+/-2	25+/- 2

NOTE:

As we know that different products are of different thickness hence the gap at the point of coating is to be adjusted accordingly . This is done by incorporating a Leader base inbetween the two products as below.



Before coating process starts in order to achieve the necessary temperature condition in the coating area all the 10 blowers are made to run idly for about an hour . Then coating process begins.

UTILITIES in coating:

+2 degree C cold water (process)

+7 degree C chilled water

-7 degree C chilled brine

90 deg C hot water (process)

90 deg C hot water (building HVAC)

160 deg C hot water dehumidification units.

The following combinations are used in different areas as mentioned below

- 2 deg C and +7 deg C water drier
- 90 deg C and +2 deg C water
- 90 deg C building HVAC and +7 deg C room conditioning.

5.3 CONVERSION:

The coated basefilm is taken for quality tests and after approval from quality department the base film is taken for conversion department. In this department the coated basefilm is cut into different sizes required by the customers.

Here converting the coated base film into different sizes is achieved by employing two machines.

- Machine I –for longitudinal cutting
- Machine II- for cross cutting

UTILITIES in conversion :

- 90 deg C building HVAC -- only for room condition.
- +7 deg C water

After conversion , the finished products goes to package , stored in stores and finally dispatched to the customers.

5.4 UTILITIES:

Utilities department becomes the bone for successful operation of the whole plant. Utilities department prepares the following and supplies to the various sections / departments.

AIR Compressed air at 6kg/sq.m pressure (operates all valves)

-2 deg C chilled brine -to prepare 2deg C water

(specific gravity –1.054) to maintain cold room at 5 deg C

Ethylene glycol-F.P-15deg C to the paper conditioning MSU

+7 deg C chilled water - to all MSU/CB* chill zone

-7 deg C chilled brine - coating area chill zone coil boxes

90 deg C hot water(process) - MSU and H2O jackets

90 deg C hot water - MSU / CB

(building HVAC)

2 deg Ccold water (process) – MSU and H2O jackets

160 deg C hot water - by air ,90 deg C heat exchanger

Steam - MSU

Water treatment - process water

[*CB -Coil boxes]

To supply to all the above it makes use of

- Boiler plant
- R & A/C plant
- Water treatment plant
- MSU

5.4.1 BOILER PLANT:

Produces hot water and steam

160deg C water at 2 kg/sq.cm pressure

175 deg C steam at 9kg/sq.cm pressure

5.4.2 R AND A/C PLANT:

Refrigeration compressors run one hour before program.

-2 deg C Ethylene glycol

+7 deg C cold water

-7 deg Ethylene glycol

By different combination of Boiler output and refrigeration output different temperature are produced.

5.4.3 WATER TREATMENT PLANT :

This supplies the process water to

- Cooling tower when required

- Boiler feed water
- Demineralisation plant – distilled water
- General purpose like hand washing , gardening ,etc.

Here 3.5 KW pumps are used once in 15 days to pump portable water to sintex tanks at different floors.

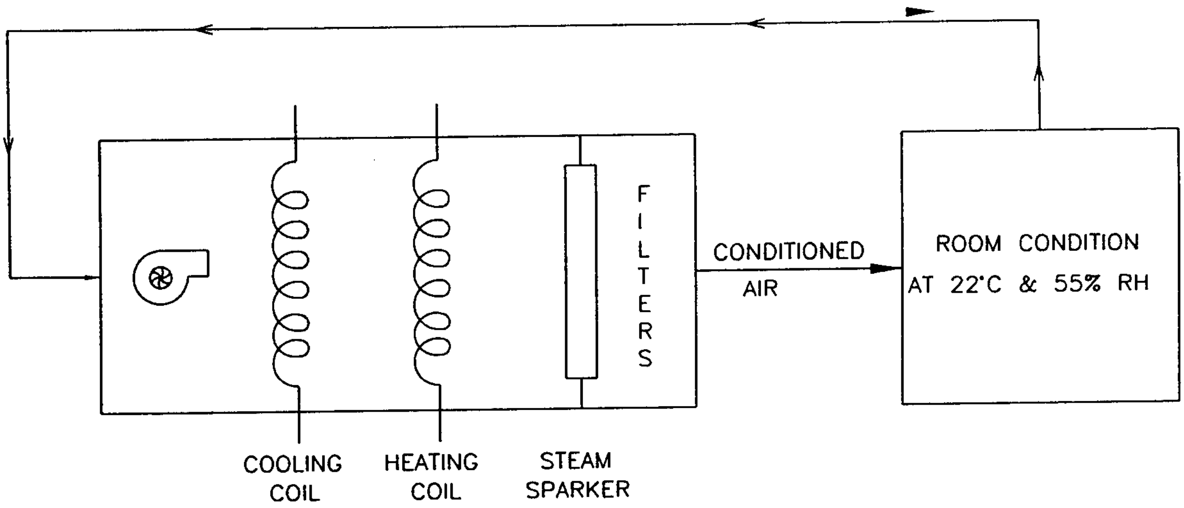
5 KW pumps are used to pump the treated water to storage tank. 3 pumps are used.

One is used and the remaining two are standby.

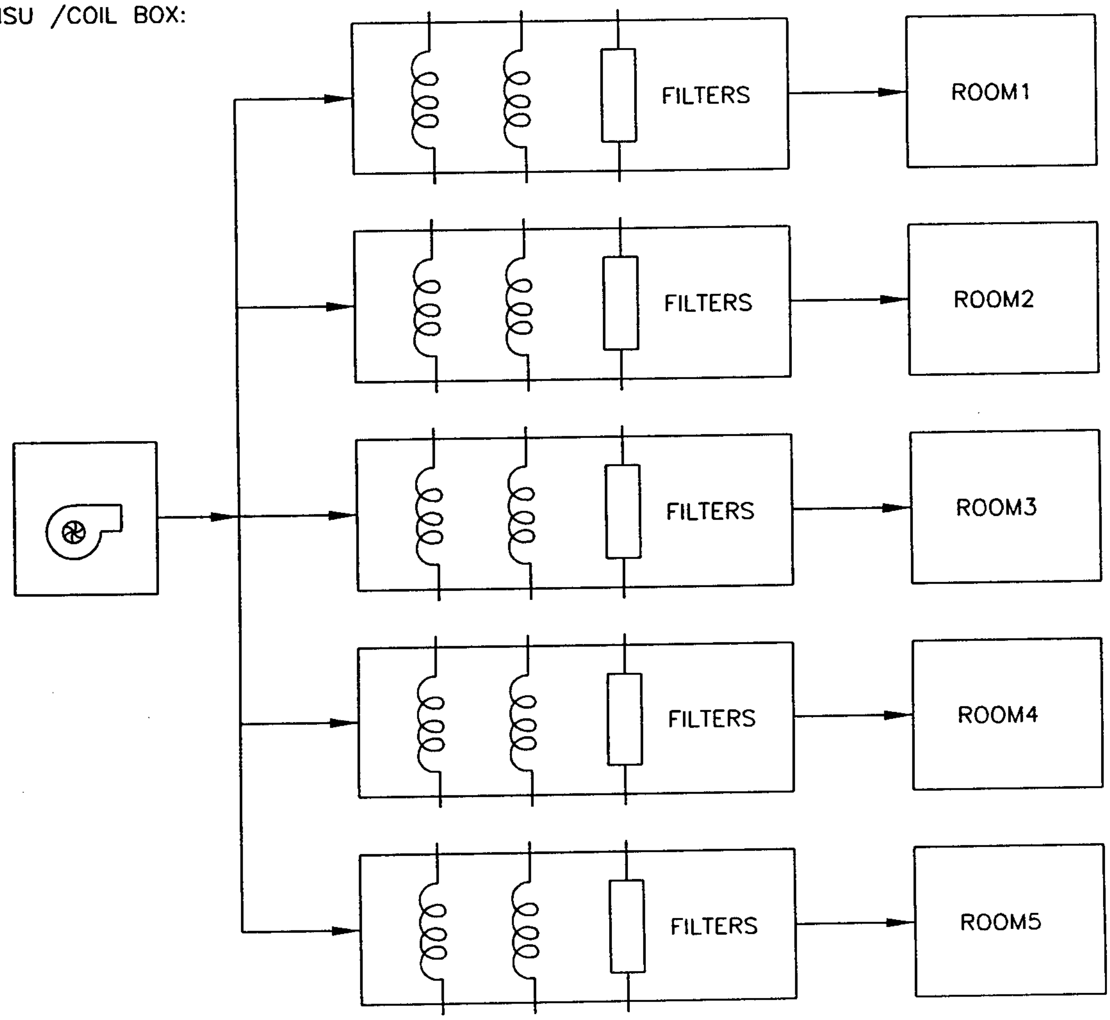
5.4.4 MSU (MAIN SUPPLY UNIT):

MSU is used to produce the room conditions at 22 deg C and 55% RH .The block diagram is shown below:

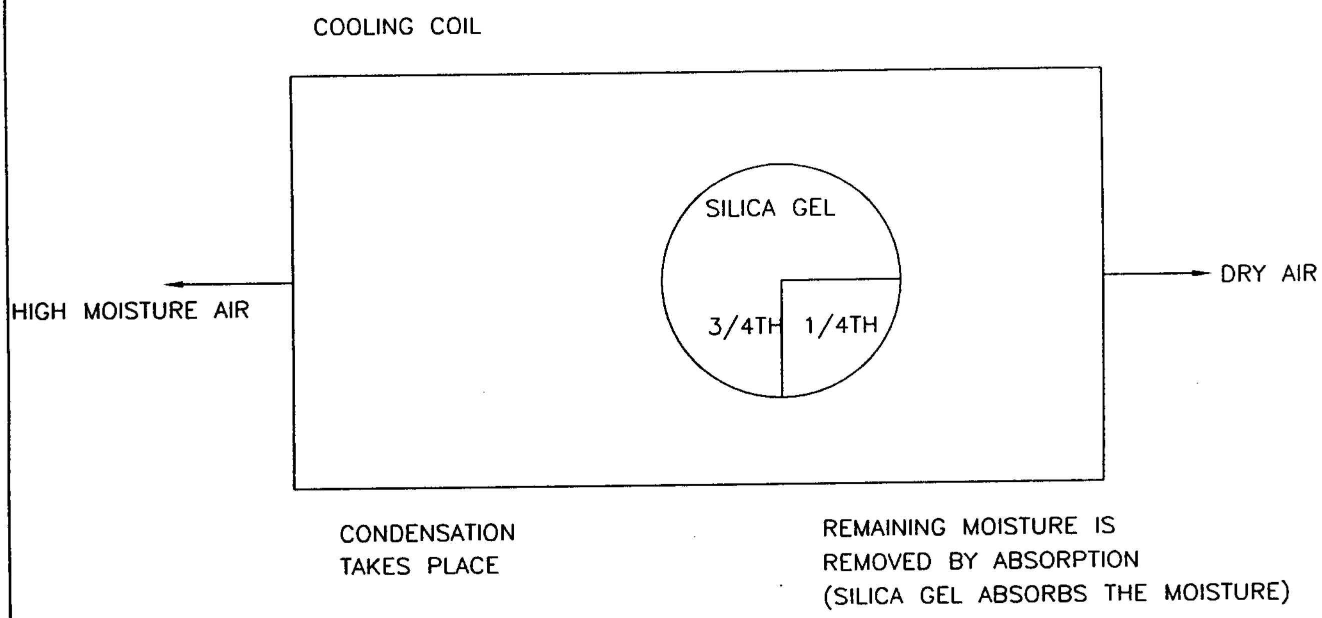
MSU :- BUILDING



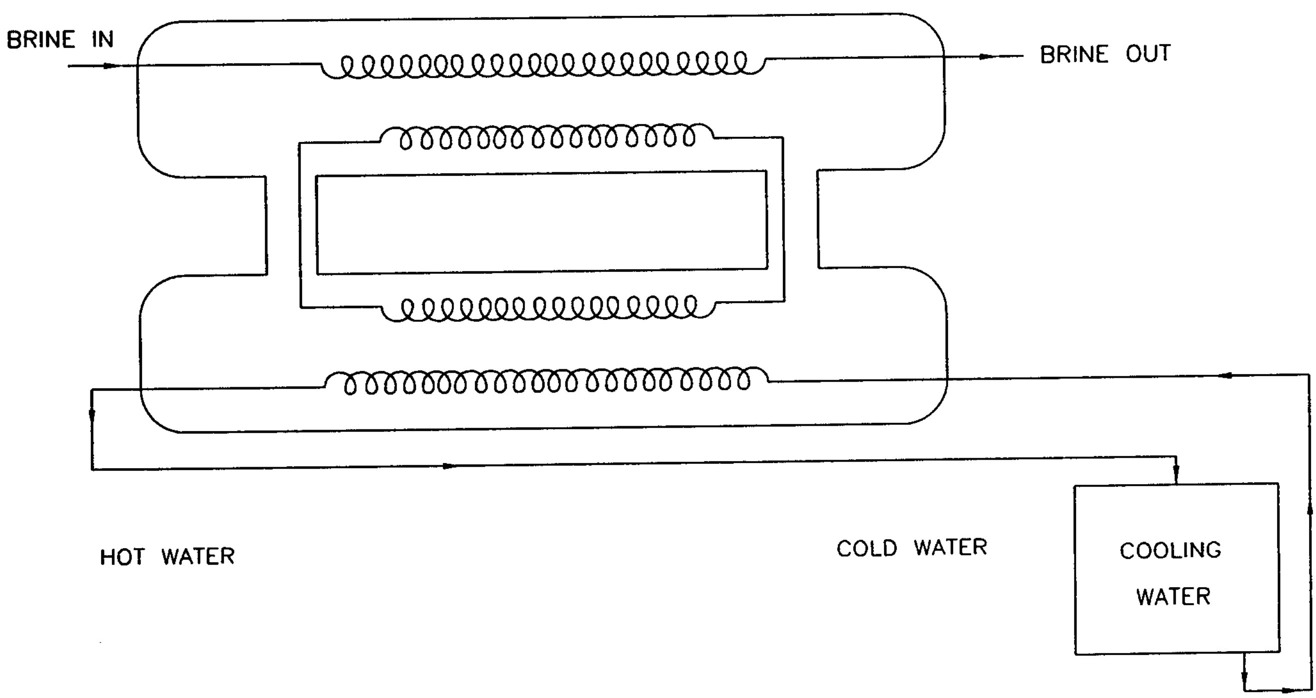
MSU /COIL BOX:



MSV / DEHUMIDIFICATION UNIT



R & A/C PLANT



6. PERFORMANCE EVALUATION

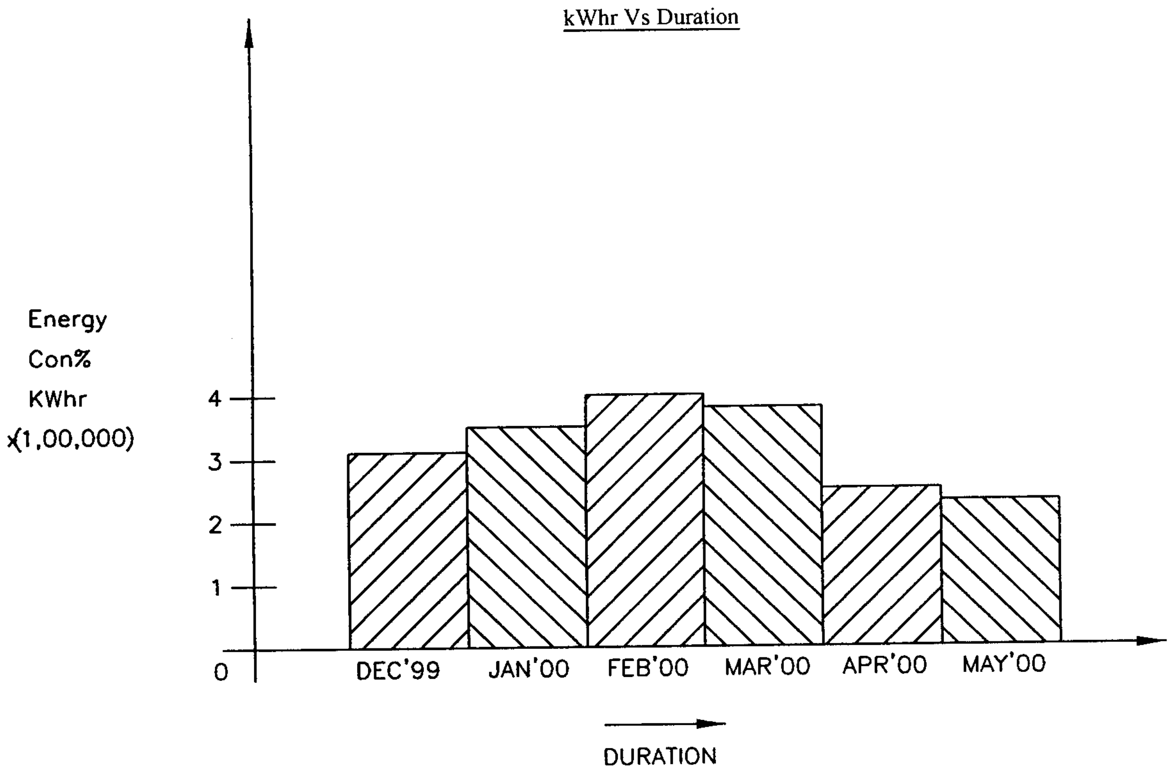
6.1 MONTHLY PRODUCTION REPORT:

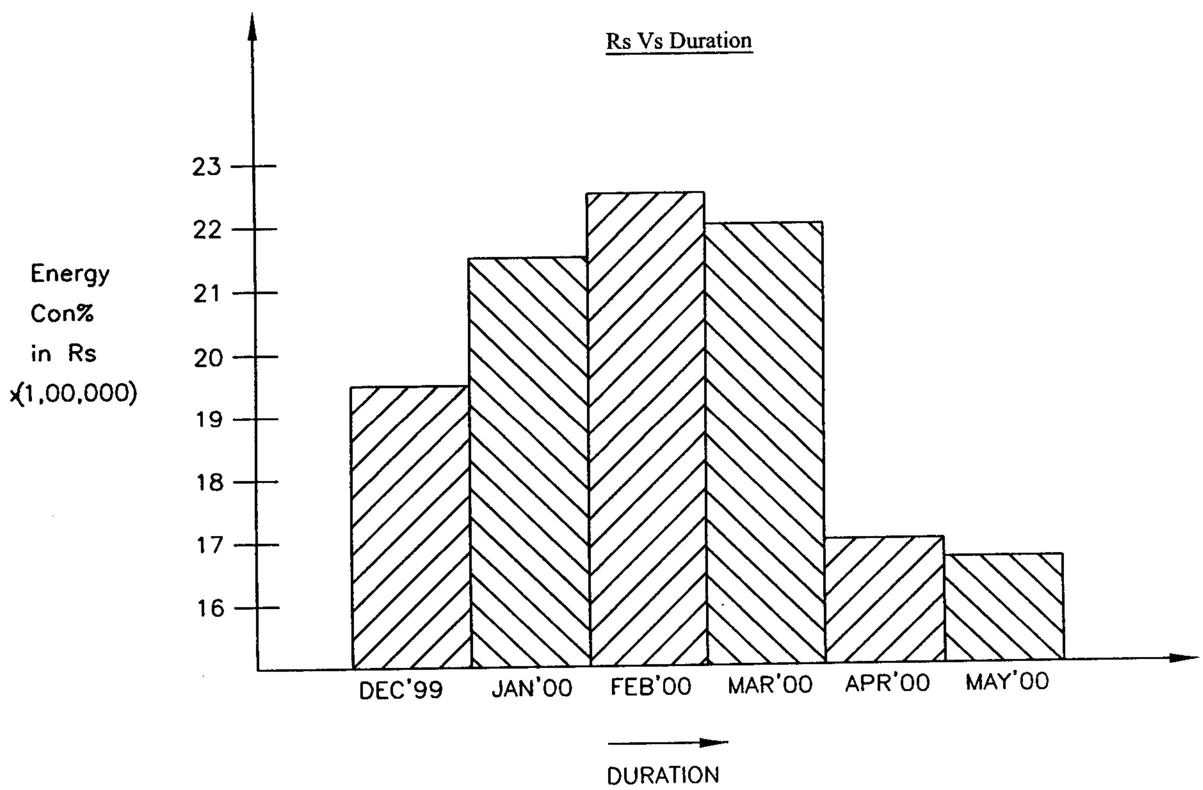
MONTHS	PRODUCTS	PRODUCTION Total(Sq.M)	PRODUCTION Rejection(Sq.M)	OUTPUT/MONTH (Sq.M)
Dec '99	Medical X-ray	24,867	3,028	
	Industrial X-ray	2,137	150	
	Green Sensitive ortho (MX-ortho)			
	MMR			
	MIF			
	ADP			
	Graphic Arts			27,004
Jan 2000	Medical X-ray	55,970	4,844	
	Industrial X-ray	7		
	Green Sensitive ortho (MX-ortho)	648		
	MMR	691		
	MIF			
	ADP			
	Graphic Arts			58,852
Feb 2000	Medical X-ray	73,554	5,423	
	Industrial X-ray	2,387	905	
	Green Sensitive ortho (MX-ortho)			
	MMR			
	MIF	1,536	588	
	ADP			
	Graphic Arts			75,941
Mar 2000	Medical X-ray	1,28,817	9,419	
	Industrial X-ray	1,221	306	
	Green Sensitive ortho (MX-ortho)	2,218	1,182	
	MMR			
	MIF			
	ADP			
	Graphic Arts			1,32,256

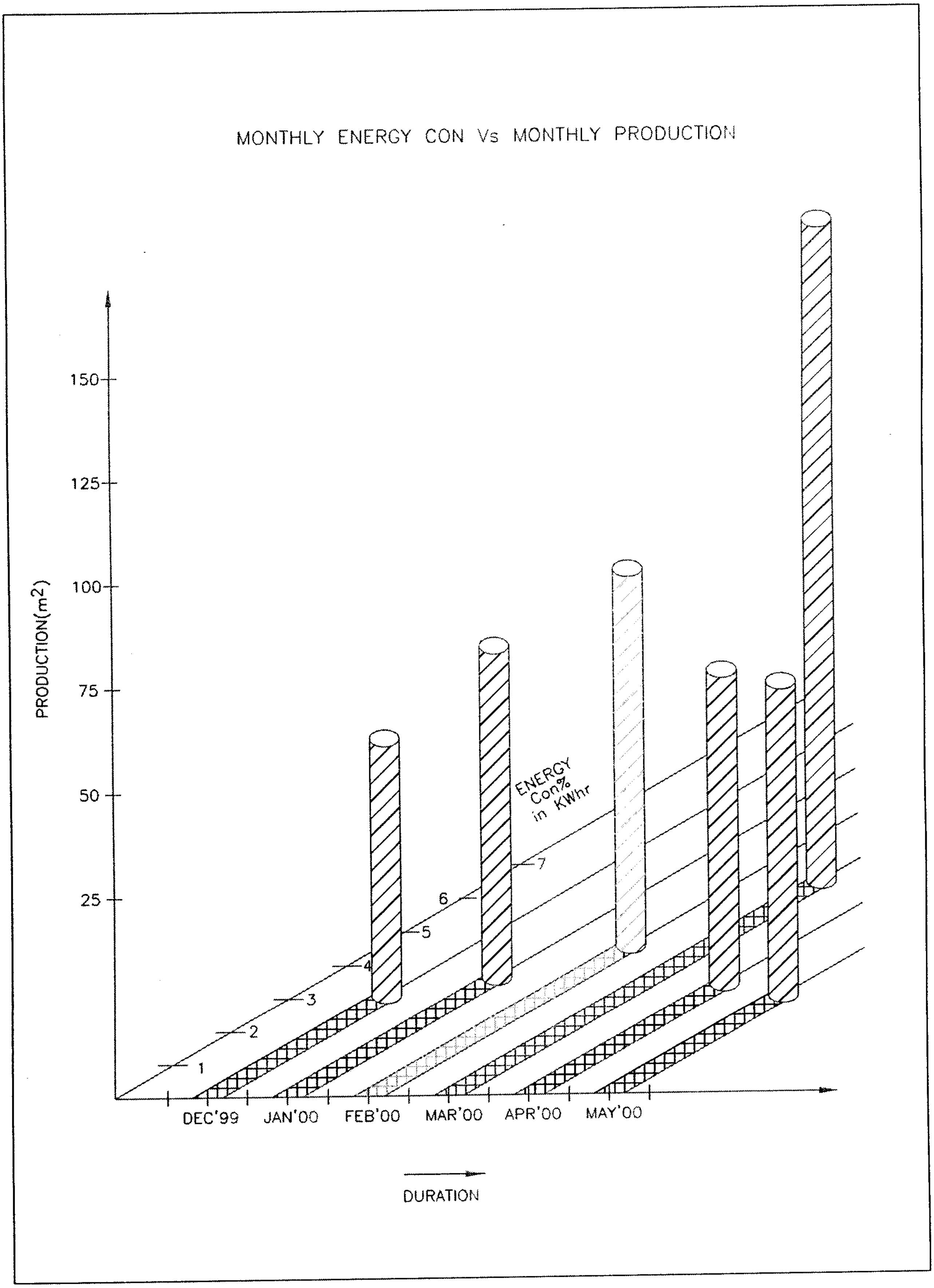
PERFORMANCE EVALUATION

MONTHLY PRODUCTION REPORT:

MONTHS	PRODUCTS	PRODUCTION Total(Sq.M)	PRODUCTION Rejection(Sq.M)	O/P/MONTH (Sq.M)
Apr 2000	Medical X-ray Industrial X-ray Green Sensitive ortho (MX-ortho) MMR MIF ADP Graphic Arts	47,755 1,071 1,209	4,835	50,035
May 2000	Medical X-ray Industrial X-ray Green Sensitive ortho (MX-ortho) MMR MIF ADP Graphic Arts	22,999 1,460 946 354	5,493 396	25,762


kWhr Vs Duration
Energy
Con%
KWhr
x(1,00,000)
4
3
2
1
0
DEC'99
JAN'00
FEB'00
MAR'00
APR'00
MAY'00
DURATION


Rs Vs Duration
Energy
Con%
in Rs
x(1,00,000)
23
22
21
20
19
18
17
16
DEC'99
JAN'00
FEB'00
MAR'00
APR'00
MAY'00
DURATION


MONTHLY ENERGY CON Vs MONTHLY PRODUCTION
PRODUCTION(m2)
150
125
100
75
50
25
ENERGY
Con%
in KWhr
1
2
3
4
5
6
7
DEC'99
JAN'00
FEB'00
MAR'00
APR'00
MAY'00
DURATION

6.2 MONTHLY PERFORMANCE OF PXP

Month	Electricity Consumed (Kw/Hr)	Production (including rejection)	Rejection	Output
Dec '99	3,30,150 units	27,004 sq.m	3,178 sq.m	23,826 sq.m
Jan '00	3,83,400 units	58,852 sq.m	4,844 sq.m	54,004 sq.m
Feb '00	4,02,150 units	75,941 sq.m	6,916 sq.m	69,025 sq.m
Mar '00	3,83,550 units	1,32,256 sq.m	10,907 sq.m	1,21,349 sq.m
Apr '00	2,44,650 units	50,035 sq.m	4,835 sq.m	45,200 sq.m
May '00	2,32,650 units	25,762 sq.m	5,899 sq.m	19,873 sq.m

6.2.1 ANALYSIS

- Dec '99 to Jan '00 –Increase in Electricity due to increase in production.
- Jan '00 to Feb '00 –Increase in Electricity due to increase in production.
- Feb'00 to Mar '00 –Decrease in Electricity due to increase in production.
- Mar '00 to Apr '00 –Decrease in Electricity due to decrease in production.
- Apr '00 to May '00 -Decrease in Electricity due to decrease in production.

6.2.2 CALCULATION OF ENERGY CONSUMPTION PER SQ.M PRODUCTIION:

In Dec '99 , for 27,004 sq.m production ,Energy Consumption is 3,30,150 units.

(i.e.) 27,004 sq.m = 3,30,150

for 1 sq.m production , energy consumption = $\frac{3,30,150}{27,004}$

= 12.23 KwHr/sq.m

Similarly,

In Jan 2000 , for 1 sq.m production, energy consumed= $\frac{3,83,400}{58,852}$

=6.5 KwHr/sq.m

In Feb 2000 , for 1 sq.m production, energy consumed= $\frac{4,02,150}{25,941}$

=15.5 KwHr/sq.m

In Mar 2000 , for 1 sq.m production, energy consumed= $\frac{3,83,550}{1,32,256}$

=2.9 KwHr/sq.m

In Apr 2000 , for 1 sq.m production, energy consumed= $\frac{2,44,650}{50,035}$

=4.8 KwHr/sq.m

In May 2000 , for 1 sq.m production, energy consumed= $\frac{2,32,650}{25,732}$

=9.03 KwHr/sq.m

6.2.3 FINDINGS:

- Energy consumption is less in March 2000 with a large production output. This is because of continuous running of the plant , during March 2000.
- Energy consumption will increase if there is discontinuity in production. This is due to ideal running of blowers, compressors , boilers , water treatment plant.

- Hence these ideal running should be minimised or there should not be discontinuity.
- Discontinuity can be avoided by giving proper planning between each department (or) proper co-ordination between each department.
- Also heat energy from Boiler can be converted into Electrical energy and stored which can be used at some other departments or areas , as and when required or continuously.

6.2.4 SUGGESTION

1. As the products produced are very less only a small quantity of products are stored inLarge cold room which consumes a very high energy to maintain 5 degree C throughout the room. Hence the size of the cold room is to be reduced thereby energy consumed can be minimised.
2. Ideal running of blower for one hour before coating starts can be minimised by giving proper planning between each departments so that as the coating of one product is finished the emulsion for next product should come to the point of coating so that continuity will be maintained between one product to another thereby idle running of blowers can be reduced which saves a high amount of energy.

Also planning is required when the blowers are to be put on so that the required temperature is obtained at the correct time at which the coated base film comes into the drying section.

Two deareators can be provided for avoiding idealblower running (ie) Engaging two deareators for two different emulsions.

- Two lines are ready at the point of coating
- When coating of one product is over, the base film for another product should come to the point of coating the other emulsion line is applied on the second basefilm.
- For changing of one base film to other a lead base film is used, the length of lead base film is to be reduced to reduce the time of arival of new base film and hence power consumed or energy consumed

3. Two machines are seperately used in conversion department one for longitudinal cutting and the other for lateral cutting. Idea is suggested to perform these two operations in one machine itself thereby the energy consumed in conversion department can be reduced to nearly 50% (includes manpower, electricity, heat energy, etc).

4. As distilled water is used in small quantities only at Emulsion (solution preparations) and coating (cleaning dye (ie) point of coating) departments, the pumps employed in preparation of distilled water can be minimised, which saves energy.

5. If there is any repair in utilities side, thent he time required for doing repair work should be gien correctly to avoid unneccessary running of blower, thereby the power consumed by the blowers can be reduced.

   For this, quick identification of problem of breakdown is necessary and the correct time fo its rectification is also to be mentioned accurately.

6. Suggestions for puting off the lighs during rea break, lunch bread, etc which saves considerableamount of energy. This has been already implemented.

7. Unneccessary breakdown of instruments, valves, regulators, gauges, etc due to its misuse by labours/ operators leads to stoppage of the process hence clear instructions should be given to them and right man for the right job is to be implemented. Operators should know the importance of each operations, instruments and its priciseness.

   Also if any instruments goes out of function, the operators are instructed to inform that to the maintenance people avoiding their own attempt.

8. Correct usage of cold room.

   - Unwanted usage by Emulsion department.
   - Unwanted usage by Research department (ie) by keeping emulsion in cold room and conducting trials by not giving correct time of using that emulsion.

7. SCHEDULING

7.1 EXISTING WORK SCHEDULE

In scheduling the daily operation of the company is noted for a period of two months (March and April of 2000).

The existing work schedule is clearly represented in the following tabulations.

After thorough analysis of the existing work schedule, It was found that most of the days were left idel for most of the departments. As the company has declared all Saturdays and Sundays as weekly holiday, the no. of approximate idle days in a months counts to ten to fifteen days. Hence the approximate no. of working days counts to fifteen to twenty days ina month.

Also the existing work schedule shows discountinued way of production which results in high energy losses. This way of energy loss can be reduced by making the production continuous by giving continuous work schedule.

Hence it is proposed to give continuous work schedule for the first 15 days in a month. As the conversion department is always loaded for a whole month, for the remaining fifteen days only coating and emulsion departments are being possibility to be idle. During the idel period of these two departments, some of the labours in these two departments can be used for maintenance work of their respective departments while the rest is proposed to be used for the distilled water plant where the excess water stored in the distilled water tank is bottled and can be sold at a profitable price.

As it is already been proposed for a continuous work schedule during first fifteen days in a month, the following flow chart clearly guides to follow up with the continuous work schedule.

Date	EMUSLION			COATING			CONVERSION		
	S T	E D	I T	S T	E D	I T	S T	E D	I T
1/3				4.28	18:28	Intr	Continous running		Intr
2/3									
3/3				14.05	16:06				
4/3	[redacted]								
5/3									
6/3									Intr
7/3	6.00	15.00	Intr						Intr
8/3	6.00	15.00	Intr						
9/3	6.00	15.00		3.34	Cntd	Intr			
10/3				Cntd	8:30	Intr			

Date	EMUSLION			COATING			CONVERSION		
	S T	E D	I T	S T	E D	I T	S T	E D	I T
11/3	[redacted]								
12/3									
13/3							Continous running		Intr
14/3	11.45 a	20.45	Intr	Cntd					
15/3	12.00 a	21.00	Intr	15:30		Intr			
16/3									Intr
17/3									
18/3	[redacted]								
19/3									
20/3									

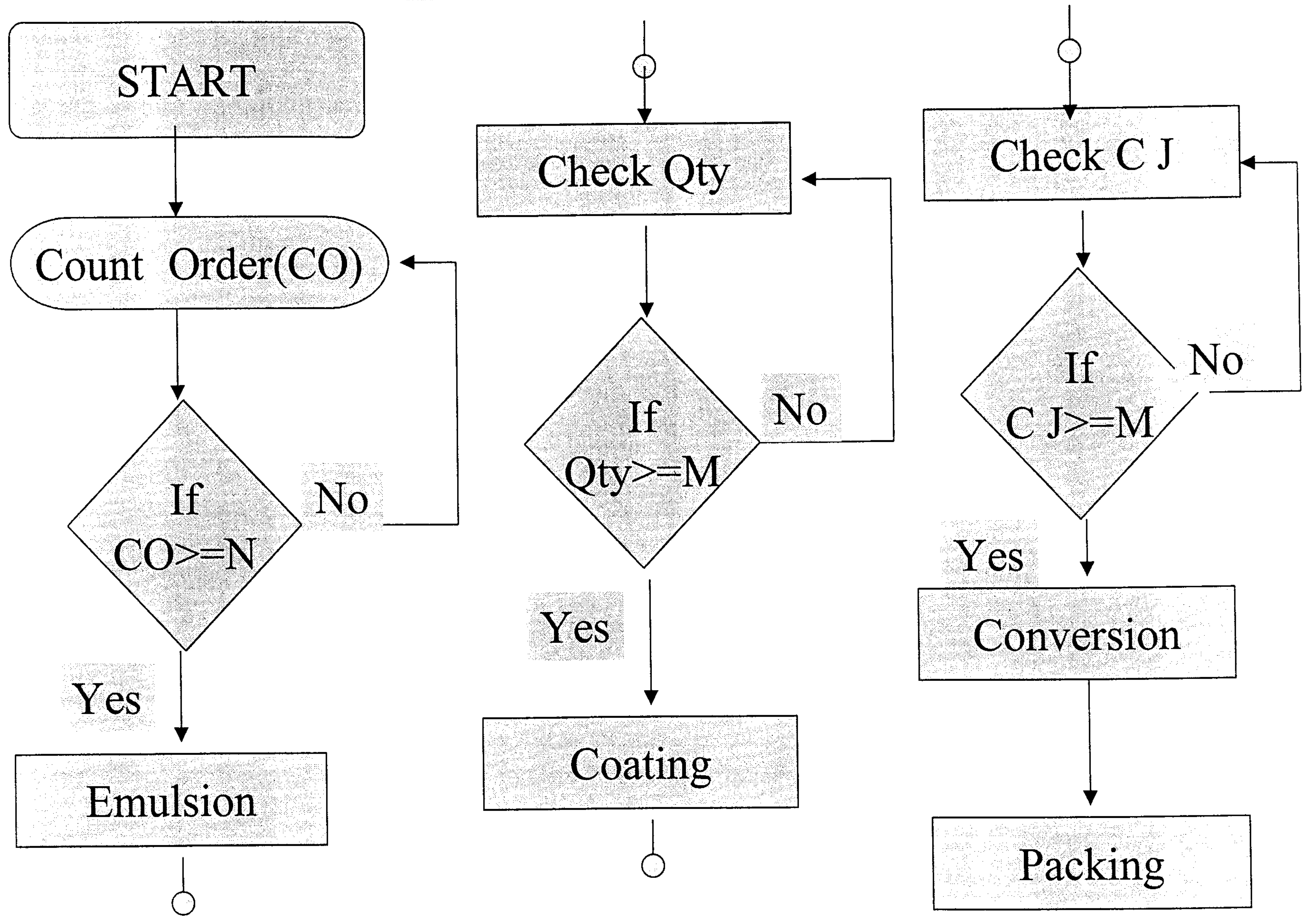
Date	EMUSLION			COATING			CONVERSION		
	S T	E D	I T	S T	E D	I T	S T	E D	I T
21/3							Continous running		
22/3	6.00 a	15.00							
23/3				21.03	Cntd	Intr			
24/3				Cntd	10:36	Intr			
25/3	[redacted]								
26/3									
27/3									
28/3									
29/3									
30/3									
31/3									

Date	EMUSLION			COATING			CONVERSION		
	S T	E D	I T	S T	E D	I T	S T	E D	I T
1/ 4	[redacted]								
2/ 4	[redacted]								
3/ 4									
4/ 4	6:00	15:00							
5/ 4									
6/ 4				16: 17	Contd	Intr			
7/ 4				Contd	1: 03	Intr			
8/ 4	[redacted]								
9/ 4	[redacted]								
10/ 4									

Date	EMUSLION			COATING			CONVERSION		
	S T	E D	I T	S T	E D	I T	S T	E D	I T
11/ 4									
12/ 4									
13/ 4									
14/ 4									
15/ 4	[redacted]								
16/ 4									
17/ 4									
18/ 4									
19/ 4									
20/ 4				2:05	Cntd	Intr			

Date	EMUSLION			COATING			CONVERSION		
	S T	E D	I T	S T	E D	I T	S T	E D	I T
21/ 4				Cntd	15:41	Intr			
22/ 4									
23/ 4									
24/ 4	6:00	16:00							
25/ 4									
26/ 4									
27/ 4	9:00	18:00	Intr						
28/ 4				10:17	11:14				
29/ 4									
30/ 4									

Flow Chart for Dynamic Scheduling



8. LAYOUT OF CONVERSION DEPARTMENT

8.1 EXISTING CONVERSION DEPARTMENT

8.1.1. MAN POWER IN EXISTING CONVERSION DEPARTMENT

Slitting Machine :

In thus m/c, the speed of the coated film is 100m/min. The following employees take incharge of slitting process.

*	Senior operator	-	1 no. (controls the m/c operation)
*	Helper	-	2 nos. (Jumbo loading storing slits in storage)
*	Sampler	-	1 no. (For giving samples to P.C.)

Cross - Cutting Machine :

In this m/c, speed of the slitted film is 50m/min. The following employees take incharge of cross-cutting operation.

*	Sr. Operator	-	1no. per m/c. (controls the m/c operation)
*	Helper	-	1 no. per m/c.
*	Sampler	-	1 no. per m/c.
*	Unwinding operator	-	1 no. per m/c.
*	Collecting the cut film	-	1 no. per m/c.

Corner rounding

Just rounds the sharp corners. Four machines are employed with one operator each.

Inspection :

Two inspection sections are there with fifteen operators and one helper in each section.

Shear Cutting

This operations is done to remove the damaged edges. One operator and one helper are employed in this section.

Sealing

Here the impected film is kept inside the cover to sealed. This operation uses two operators each total four operators.

Final packing

The sealed packs are kept inside the boxes with the help of ten helpers.

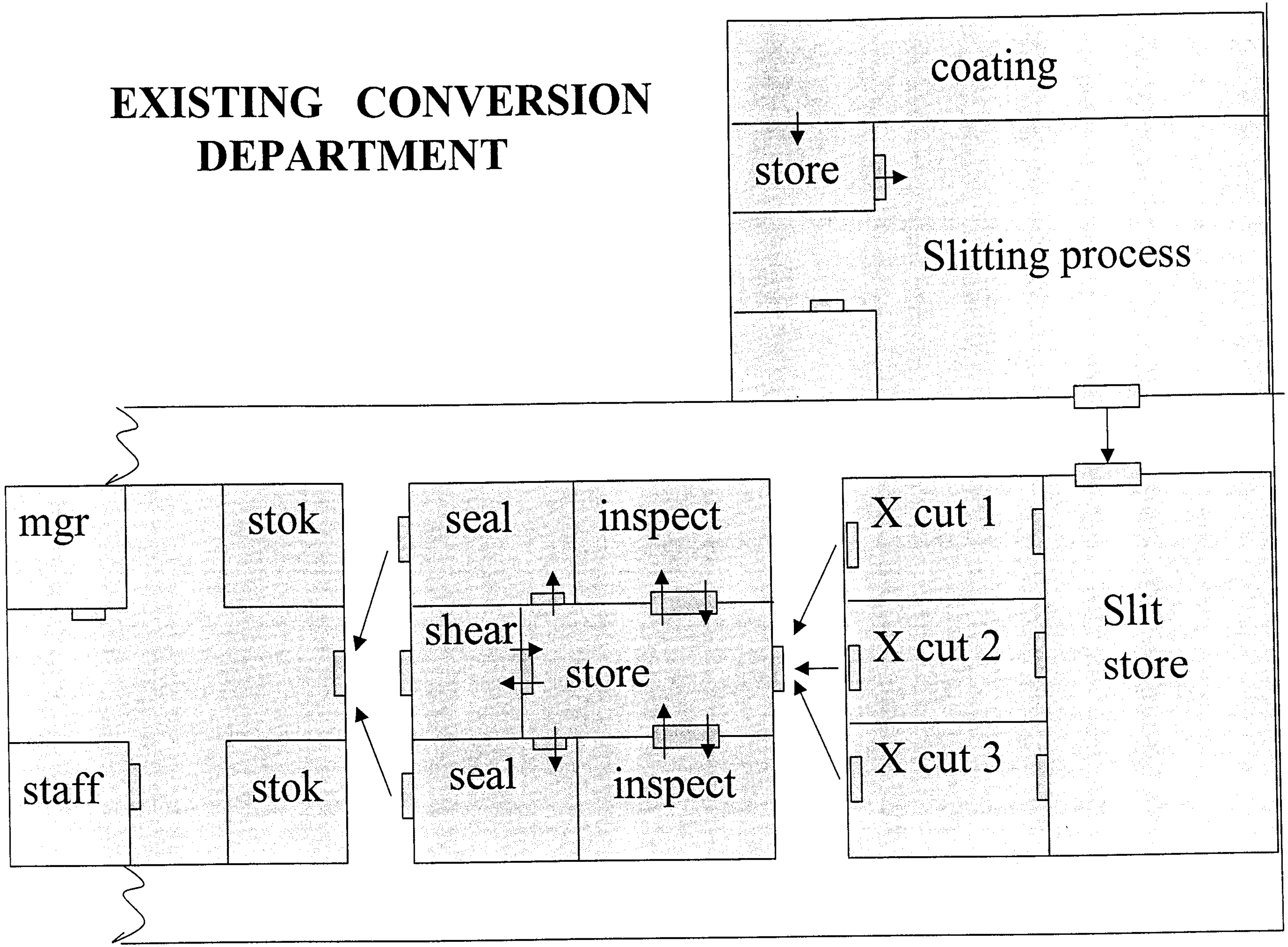
8.2. PROPOSED CONVERSION DEPARTMENT

The total manpower in slitting & cross cutting counts to nine numbers which in proposed conversion department is reduced to four numbers as both slitting and cross cutting operations are performed in one machine. Thereby manpower saving counts to five numbers. These four numbers are

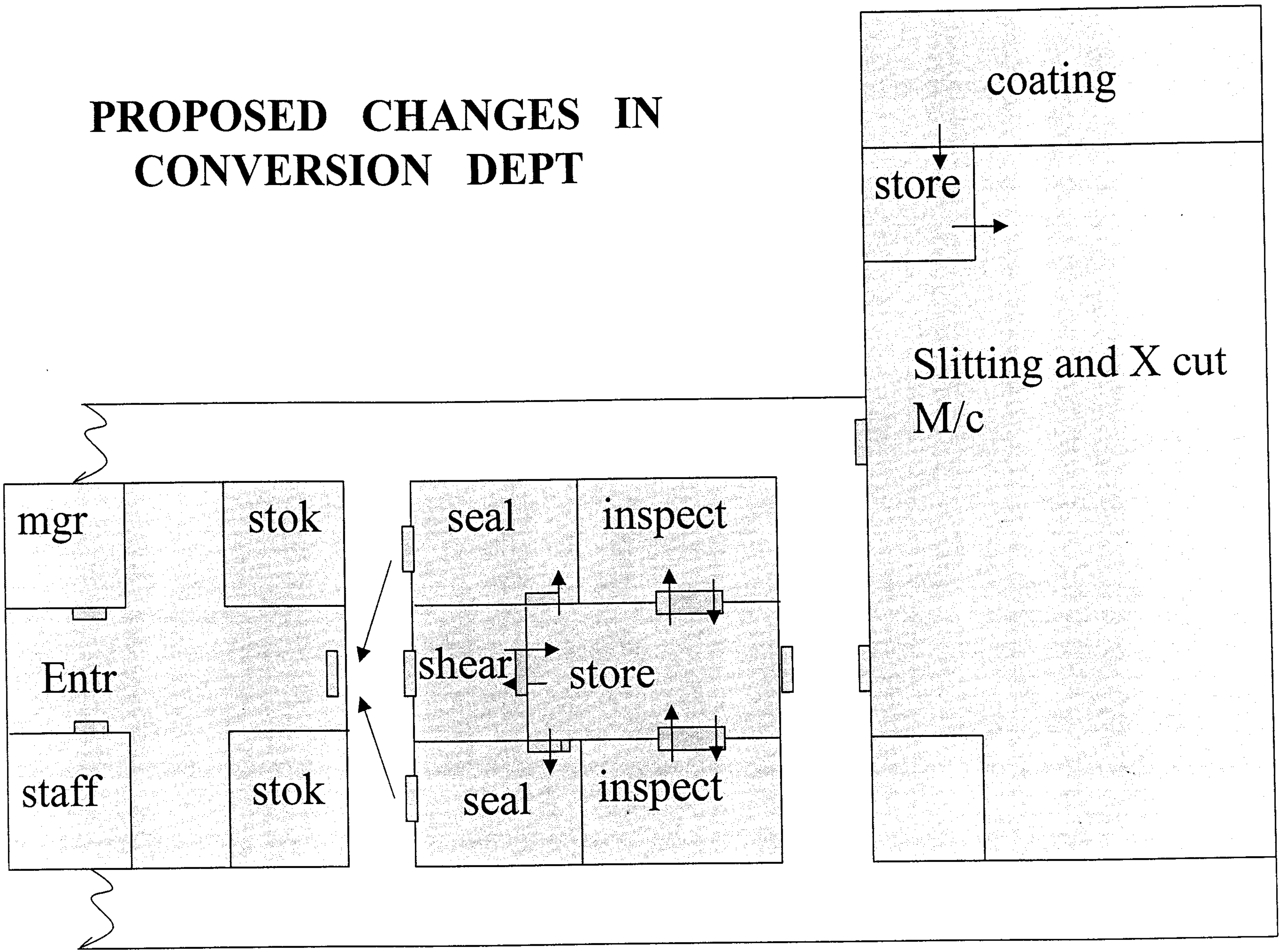
* Senior operator - 1 no.
* Picker - 2 nos.
* Helper - 1no.

Also the speed of the film is increased from 50m/min to 60m/min so as to increase the productivity.

EXISTING CONVERSION DEPARTMENT



PROPOSED CHANGES IN CONVERSION DEPT



ESTIMATION OF ENERGY CONSERVATION

(a) COLD ROOM

Existing		Proposed		Energy Saved
Copressor Capacity	Energy Con./hr	Copressor Capacity	Energy Con./hr	
265 ton of refrigration and 24.5 kw	171.5units	4 tons of refrigration and 7.5 kw	5.25units	11.9 units approx = 12 units

SPECIFICATION OF COMPRESSORS

LARGER COLD ROOM	SMALLER COLD ROOM
24.5KW	7.5KW
2975rpm	1450rpm
6600V	415V
28Amps	15Amps.
Induction motor.	Induction motor.
Kirlosker Electrical Company	Kirlosker Electrical Company

(b) **IDLE RUNNING OF BLOWERS IN COATING** :

ENERGY CONSUMPTION PER BLOWER PER HOUR = 38.5 units

THEREFORE ENERGY CONSUMPTION BY 10 BLOWERS PER HOUR = 385 units

* SPECIFICATION OF BLOWER :

Fan make	:	Keymere Bagshawe
Fan model	:	D – 51 – 295 DIDW
Fan capacity (CMH)	:	26640
Static pressure (MMWG)	:	149
RPM	:	2071
Motor make	:	Kirlosker Electrical Co. Ltd

(c) **CONVERSION DEPARTMENT**:

EXISTING DEPARTMENT	PROPOSED DEPARTMENT	ENERGY SAVED
• Two separate machines are used (i) Slitting machine (ii) Cross cutting machine	• A single machine does the function of both Slitting & Cross cutting machines	200 units
• Total energy consumption per day =3000	• Total energy consumption / day =2800	

SPECIFICATION OF CONVERSION MACHINES :

*(i) SLITTING M/C :

Motor Name	Make	Kw	Armature		Field		RMP
			Volts	Amps	Volts	Amps	
Main drive	Siemens	2.15	400	6.4	310	0.15	2000
Scrap winder	Siemens	2.15	400	6.4	310	0.15	2000
Unwind motor	Siemens	4.50	400	13	310	0.20	2630
Rewind motor	Siemens	4.50	400	13	310	0.20	2630

(ii) CROSS CUTTING M/C :

Motor Name	Make	Kw	Armature		Field		RMP
			Volts	Amps	Volts	Amps	
Unwind motor	Siemens	2.95	260	13	180	0.28	2290
Turret motor	Siemens	2.95	260	13	180	0.28	2290
Stacker motor	Siemens	4.65	220	24.5	180	1.00	1080
X-Cutter motor	Unico	17.7	240	66.0	125	3.00	524

(d) DEMINERALISATION PLANT :

* Storage capacity of the DM tank = 8500 litres .

EXISTING		PROPOSED		ENERGY SAVED
No. of pumps	**Energy cons per hour**	**No. of pumps**	**Energy cons per hour**	
2	13.02 units	1	6.51units	6.51units

* SPECIFICATION OF THE PUMP :

Motor : Induction motor .
Type : AMW160M2 .
Volts : 415V .
Power : 9.3KW .
RPM : 2890 .

DISTELLED WATER BOTTLING PLANT

Qty. of water	Qty. of water	Excess water
10 cubic metre	5 cubic metre	5 cubic metre

- Size & Capacity of storage tank = 25,000 litres .
  - Selling price of distelled water = Rs . 15 per litre .
  - Manufacturing cost = Rs . 5 per litre .
  - Income = Selling price - Manufacturing cost .

    = 15 - 5

    = Rs . 10 .

(e) **SWITCHING OFF LIGHTS** :

- Energy consumed by lights per day = 1750 units .
- Energy consumed by lights per hour = 72.99 units .
- Energy consumed by lights per mnt . = 1.21 units .
- Total break time = (Tea break) + (Lunch & Dinner)
  = (Morning + Evening + Post evening) + (Lunch + Dinner)
  = (15mnts. + 15mnts. + 15mnts.) + (40mnts. + 40mnts.)
  = 45mnts. + 80mnts.
  = 125mnts.

- ENERGY SAVED = (TOTAL BREAK TIME) X (ENERGY CONSUMPTION/MNT.)

  = 125 X 1.21

  = 151.25 units .

(f) **REPAIR TIME** :

- Total energy consumption in Emulsion dept. including utilities = 9000 units .
- Total energy consumption in coating dept. including utilities = 32000 units .
- Total energy consumption in conversion dept. including utilities = 4500 units .

- The excess time (X) to repair is the energy loss to the dependent department

Energy loss	=	Energy conservation	=	Consumption during excess Repair time .
(If they don't complete repair works within specified time)		(If the specified repair.. time is followed or implemented)		

This can be overcome by giving correct repair time to the concerned department .

Estimated savings per year

Sl.No	Source	Energy savings / year in kWh	Savings / year in RS
A	Cold room	12 / hr = 12 * 24 * 365 = 105120	105120 * 3 = 315360
B	Idle running of blower *	11* 385 * 12 = 50820	50820 * 3 = 152460
C	Conversion department	200 / day = 200 * 5 / week = 200 * 20 / month = 200 * 20 * 12 = 48000	48000 * 3 = 144000
D	D. M plant (Pump)	6.51 / hr = 6.51 * 24 / day = 6.51 * 24 * 5 /week = 6.51 * 24 * 20 * 12 / year = 37497.6	37497.6 * 3 =112493
E	Lights	151.25 / day = 151.25 * 5 / week = 151.25 * 5 * 4 / month = 151.25 * 20 * 12 / year = 36300	36300 * 3 = 108900
F	Repair time **	4.71 * 0.8 / day = 3.81 * 5 / week = 19.1 * 4 /month = 76.2 * 12 /year = 914.112	914.112 * 3 = 2742
Total		1627691.712	835955

* Average idle running = 11 hr/month

** Average excess repair time in coating / day = 48 min = 0.8 hr / day

Total energy consumption / min = 4.761 units

ESTIMATED SAVINGS PER YEAR

S.NO	SOURCE	ENERGY SAVINGS PER YEAR (Kw- hr)	AMOUNT SAVED PER YEAR (Rs)
(a)	COLD ROOM	1,05,120 units	3,15,360
(b)	BLOWER	50820 units	1,52,460
(c)	CONVERSION MACHINE	48,000 units	1,44,000
(d)	D.M. PLANT (pump)	37,497.6 units	1,12,493
(e)	SWITCHING OFF LIGHTS	36,300 units	1,08,900
(f)	REPAIR TIME	914.112 units	2,742

TOTAL → 27,8651.712 units Rs. 8,35,955

CONCLUSION

Energy conservation is various areas has become very essential as most of the industries focus their attention only on productivity rather than conserving energy which are unnecessarily being used. Hence the author adapted some of the methodologies mentioned above to the polyester x-ray project and obtained a considerable amount of energy savings in rupees per annum. As the number of industries is increasing day-by-day in future it becomes very essential for the steps to be taken towards energy conservation by all existing and emerging industries in the country so that the total energy saved may result either in cost reduction or can be used for various application as and when required.

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